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PALE INDIAN PLANTAIN (CACALIA ATRIPLICIFOLIA, ASTERACEAE) A LITTLE-KNOWN PLANT IN MICHIGAN, PART I. OBSERVATIONS ON GROWTH PATTERNS/LIFE HISTORY

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The Pale Indian Plantain, *Cacalia atriplicifolia* L. (Asteraceae) is one of two species in this genus that occur in Michigan, and one of seven in eastern North America. It occurs along the edges of woods, pastures, and occasionally roadsides, and is widely distributed from New York south to Georgia, west to southern Minnesota, eastern Nebraska, Kansas, and northwestern Missouri (Pippen 1978). Michigan is near the northern edge of its range. Herbarium specimens and reports of occurrences of this plant in Michigan indicate that its distribution is mostly in the southern part of the state (Fig. 1). It is frequently mentioned as a component of prairie communities. While the flowers are relatively inconspicuous, the height of the plant (to about two meters) and striking appearance of the leaves (dark green above, whitish beneath, with strongly and diversely toothed edges) call attention to this plant in the field.

To gain knowledge of the plant's life history, a field study was conducted on three naturally-occurring populations located in Kalamazoo County, Michigan, from May, 1973 to November, 1975 and selected aspects have continually been observed to date (1986). Long-range life history and natural history observations are important for better understanding of these plants and the ecosystem of which they are a part.

Cacalia atriplicifolia is a robust perennial consisting of a rosette of long-petiolate, ovate-cordate basal leaves from which arises a leafy, flowering stem 1–2.5 m tall. The leaves are white glaucous on the underside hence the name Pale Indian Plantain.

The inflorescence consists of 100 or more cylindrical heads each containing five creamy-white to greenish-purple discoid flowers (Pippen 1978).

SITE DESCRIPTION

The three populations observed in this study have been in existence since at least 1964 (personal observation by RWP).

Site I is near the eastern boundary of the Blanche Hull Preserve in the City of Kalamazoo, SE ¼ of Sec. 34 of Kalamazoo Twp., T2S, R11W. The population of *Cacalia atriplicifolia* occupies an area about 4 × 8 m in and near a footpath which leads north to a creek. Here the West Branch of Portage Creek merges with Portage Creek. A relict oak-hickory forest lies directly to the south.
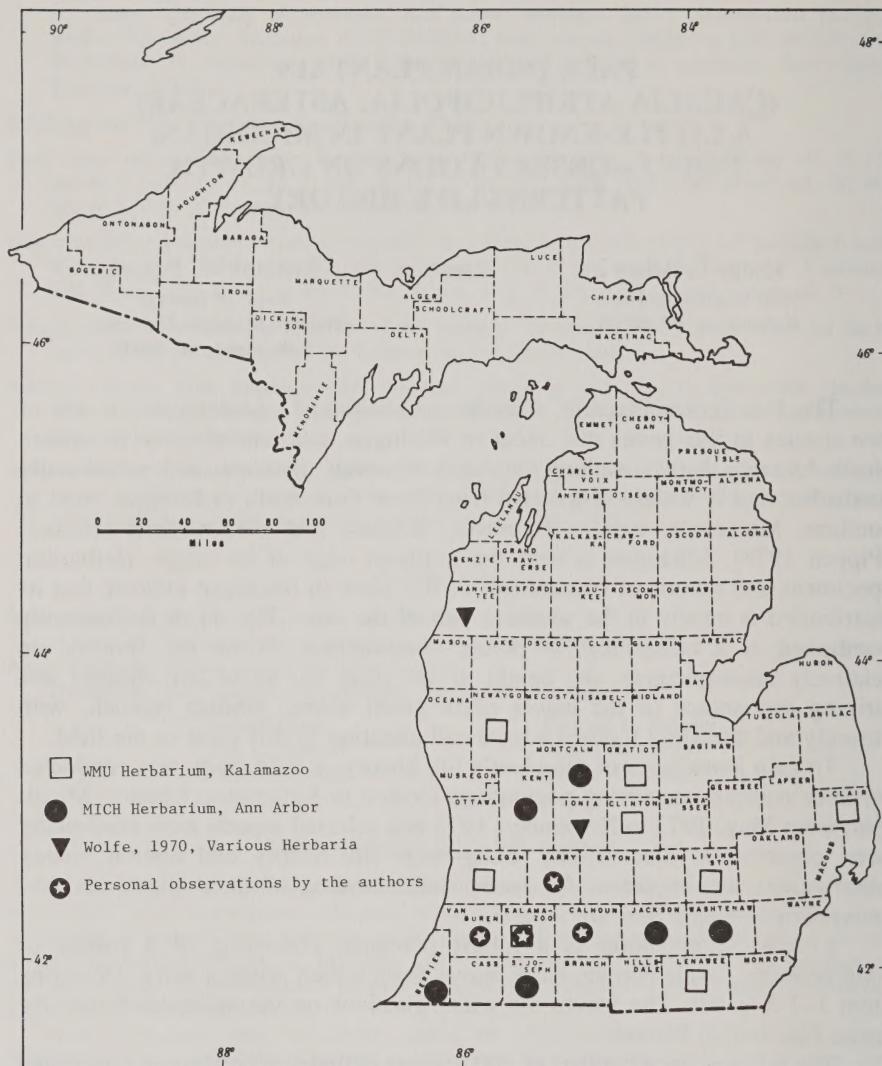
Fig. 1. Known Location by County of *Cacalia atriplicifolia* in Michigan.

Ground cover consists of nearly 100% tree litter except where foot traffic has worn it away and mosses cover most of the surface. Subsoil beneath a thin layer of humus-rich topsoil is compacted and highly resistant to probing. Soil pH is 7.4.

Site II is in the Gourdneck State Game Area along Hampton Creek in the City of Portage, NW ¼ of Sec. 19, Portage Twp., T35S, R11W. Water content of ground occupied by this population within the site varies greatly. At times near-saturation exists in floodplain areas, while conditions are often very dry in

more elevated, sandy soil. Soil pH ranges from 4.8 to 6.0. The plant association varies from shrub-carr-fen to oak-hickory forest. Ground cover varies from about 15% to 100%, and soil compaction is moderate throughout most of this area.

Site III is approximately 1.5 miles southeast of Site II, at the south and west edge of an oak-hickory forest, along Vanderbilt Road within the City of Portage, NW ¼ of the NW ¼ of Sec. 29, Portage Township, T3S, R11W. The central portion of this site consists of a formerly-cleared lot which extends from the road to the woods. Ground cover of tree litter and mosses on the sandy soil ranges from about 5% in the open to 100% within the woods. Penetrability of the soil to probing is higher here than it is at the other two sites. Soil pH is about 6.0. Plants are most concentrated on a southwest facing slope along the edge of the woods.

METHODS AND MATERIALS

The clonal nature of the vegetative rosettes of leaves of this species makes estimation of population size complicated. In this study we interpreted one plant to be any integral group of leaves which was either associated with a flowering stem or which could reasonably be expected to have been so associated in a previous year based on the size and number of radical leaves, seedlings excepted (Erickson 1967).

Where possible, seedlings were marked with color-coded plastic sticks for identification in subsequent years. At the larger Site III, the study area was divided into fifteen 10 m × 10 m quadrats. Fruits (including pappus) were weighed on a Mettler Analytical Balance Model #H16. Basal diameter of plant stems was measured with as little disturbance to the plants as possible with a calibrated device as described by Evans (1972). Leaf area of larger leaves was determined with a 100 cm guide and from tracing of intact leaves on metric-ruled paper. Limited living caudex and root observations were made by washing away soil with water from a sprayer powered by compressed air. Specimens of mildewed leaves, pollinators, and predators were identified by the Departments of Plant Pathology and Entomology at Michigan State University. Collection of possible pollinators was held to a minimum so as not to disrupt seed production, which was part of this study.

Light intensity in foot candles was determined with a Weston Light Meter. Soil penetrability was noted by dropping a vertically-oriented All-Rite Stainless Steel Ballpoint Pen with the point held at a height of 1.5 m above the ground. The depth to which the point became buried was then recorded.

To investigate the breeding system in the first year of the study, several inflorescences were enclosed in 24 cm × 27 cm clear plastic bags shortly before anthesis. In subsequent years paper and nylon bags were substituted because of potential deleterious effect of plastic bags on plant growth. Limited studies on plant growth were carried out under artificial conditions. Plants were also grown from seeds in garden plots. For indoor studies seeds were cold-stratified for 120 days at 0.3 C (32.5°F) to break dormancy, Chang (1971).

RESULTS

Growth Patterns

The First Year. Observations are summarized in Fig. 2 and Table 1. Seeds germinated in the field in May and June after the soil had warmed to nearly 21°C (70°F). Most seedlings were found within a meter or two of the location of a previous season's flowering stem. Cotyledons remained dark green and functional on many seedlings until late July but had disappeared by mid-August. The first true leaf was observed the tenth day after emergence of the cotyledons.
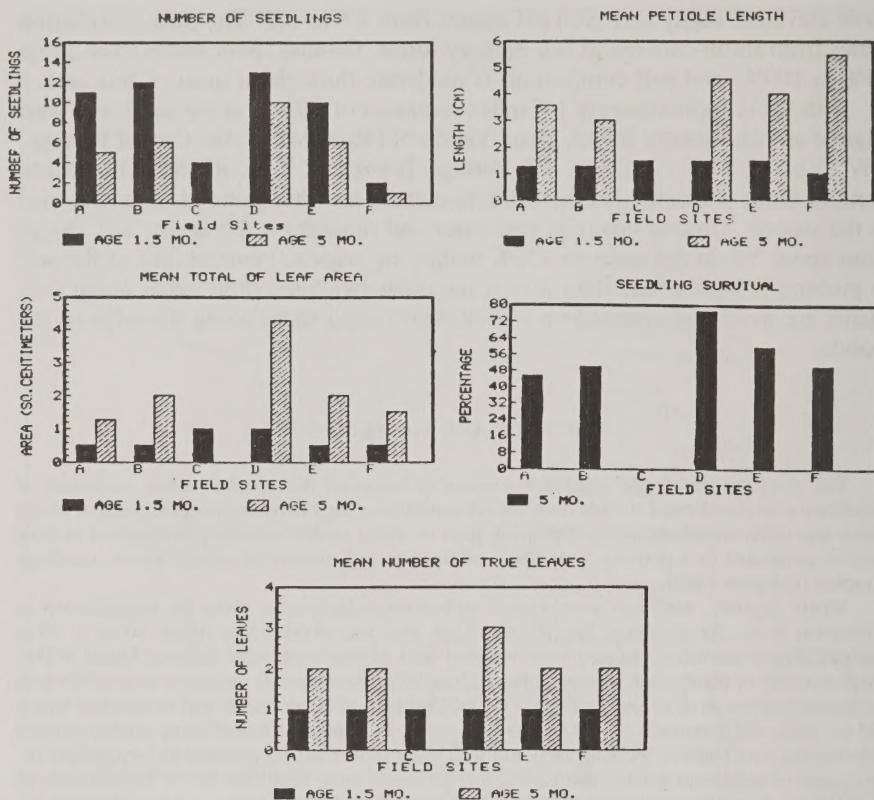
Fig. 2. Survival and Growth of First Year *Cacalia atriplicifolia* Seedlings of Selected Field Sites. Seedling age based on time from ground emergence. **Field Sites**: A: West-facing slope; 70% grass cover; moist; shade in A.M. Light to 1500 ft. candles in P.M. Temp. medium hot (Site III). B: Horizontal Surface; 50% cover; shade in A.M. full sun, P.M. Dry, hot in July and Aug. (Site III). C: Horizontal Surface; 80% cover; full sunlight at emergence, reduced to 700 ft. c. in Aug. Med. dry, med. hot (Site III). D: N-facing slope; Light 500–1000 ft. c. in P.M. Soil Med. dry to moist; Temp. moderate (Site III). E: Horizontal surface; full light at emergence; 100% *Rubus hispidus* cover cuts light to 50 ft. c. by July; hot, dry (Site II). F: NE-facing slope; open wood; understory cuts light to about 50 ft. c. Soil usually moist; Temps. moderate (Site II).

Seedling progress was observed at Sites II and III and in garden plots. No seedlings were ever found at Site I, although seeds from Site I plants germinated and grew in garden plots. As we expected, best first-growing-season seedling survival (greater leaf area and higher mean number of true leaves) occurred where light, moisture, and shelter were adequate but not extreme. Of 138 seeds which germinated in a garden plot in the spring of 1974, 90% survived the first summer, but only 30% of these survived the comparatively mild winter of 1974–1975. Overall development and survival of later cohorts closely paralleled that of this group. The caudices showed negligible development at the end of one growing season. These observations indicate that seedling growth during the first

TABLE 1. Comparison of four-month-old and two-year-old seedlings of *Cacalia atriplicifolia* grown in garden plots. (± standard deviation)

Number of Plants	Ten	Two[*]
Age of Plants (August, 1975)	4 months	2 years
$\overline{X}$ Number of Leaves	4 ± 0.9	4 ± 1
$\overline{X}$ Diameter of Petioles (cm)	0.15 ± 0.05	0.25 ± 0.1
$\overline{X}$ Length of Petioles (cm)	7.5 ± 1.0	9.0 ± 0.8
$\overline{X}$ Number of Fleshy Roots	2.5 ± 1.1	4.5 ± 0.5
$\overline{X}$ Diameter of Fleshy Roots (cm)	1	0.125 ± 0.013
$\overline{X}$ Length of Fleshy Roots (cm)	7.5 ± 1.6	8.25 ± 1.75
$\overline{X}$ Area, Largest Leaf (cm^2)	3 ± 2.9	41 ± 11.0
$\overline{X}$ Total Leaf Area on Plant (cm^2)	5 ± 2.1	76.5 ± 33.5
$\overline{X}$ Length of Caudex (cm)	0.3 ± 0.1	1.25 ± 0.35
$\overline{X}$ Dry Weight, Entire Plant (g)	—	0.52 ± 0.34

*Only two plants (one of smallest and one of largest) were available to sacrifice since most were needed for other studies.

season is not extensive, and that seedlings often enter the first winter in a tenuous condition.

The Second Year. Table 1 also describes typical variations in seedling development. In the second year the seedlings rapidly added reserves to the caudex, expanded the root system and produced radical leaves but no flowering stem. Considerable variation was noted in petiole length, number of leaves and total leaf area between individuals. In the field, after the cotyledons disappeared, it was often impossible to distinguish between the unmarked one-year and two-year old plants.

The Third Year and Beyond. If the seedling survived the second growing season and winter, rapid growth took place in the following spring and summer. Plants as generally observed were typical of mature *C. atriplicifolia*.

The Mature Plant

Radical Leaves. Leaves expand rapidly after emergence, reaching maturity by the end of June. Total leaf area produced by individual rosettes varied from about 100 cm^2 to over 4,000 cm^2, although it was often difficult to be sure that all closely associated leaves arose from a single caudex. The Leaf Area Index (total area of leaves produced/m^2) within an occupied area ranged from about .01 m^2/m^2 to about .4 m^2/m^2.

Stevens (1861) described the leaves of *C. atriplicifolia* as "thin" but we observed that the general aspect of the leaves was usually thick and sometimes almost leathery. Leaf thickness was often less within wooded, shady areas. Overall, thickness of leaves ranged from about .2 mm to .65 mm. Leaves showed stress avoidance in periods of drought and extreme heat. When temperatures reached 29.4°C (85°F) and above, considerable rolling and folding of radical leaves was observed, with the glaucous abaxial surface remaining exposed. In thicker, strongly-veined leaves, a fan-like pleating of the leaf blade was also observed.

Fig. 3. This well developed rhizome system of a four year old *Cacalia atriplicifolia* plant was grown from seed in a garden plot in 1974. By autumn of 1976 the plant consisted of one large rosette with only one caudex. During the third growing season (1977) a 2 m flowering stem was produced, but no vegetative reproduction was evident. By June of 1978 the plant had developed as shown in the photograph. The clone occupied an area of approximately 4 m². After removal of all above-ground and discernable "below ground" plant parts, numerous plantlets continued to appear throughout that summer and in subsequent growing seasons. Such production of new plants from rhizome fragments has not been previously reported for *C. atriplicifolia*. That this mechanism is an important aspect of other clone-forming plants has been described (e.g. by Moore 1979).

Leaf petioles were also affected by environmental conditions. In areas of dense growth of other species such as grasses and ferns, petioles of radical leaves of *C. atriplicifolia* were as long as 45–52 cm. In less crowded conditions, petioles 10–25 cm long were more common.

The Caudex and Root System. Harper & Ogden (1970) suggested that in higher plants the change from solely vegetative growth to reproduction depends on the accumulation of sufficient "food reserves" rather than on the age of the plant. In *Cacalia atriplicifolia*, reserve food is apparently stored in the caudex, the underground perennating organ, which is highly variable in size. The caudex also contains considerable meristematic tissue and from it originate roots, flowering stems, radical leaves, and lateral caudices or rhizomes. In one plant we observed, over time, that the caudex had branched to produce at least 16 lateral caudices, or fleshy rhizomes, each of which produced a rosette of leaves, thus forming a large clone. Similar patterns were noted in the sandy soil at the edge of the woods in Site III and in the well-worked soil of a garden plot (Fig. 3).

Population studies in vegetatively-propagating clonal perennials are difficult because it is hard to distinguish individual plants from clonal ramets (Cook 1983). Plants which are or have been connected by rhizomes are, of course,

genetically identical but the existence of underground connections often cannot be deduced with certainty. In areas of high soil penetrability, the thick, fleshy rhizomes sometimes extend 30 cm before ramets are formed. However, at Site I where soil penetrability is limited, rhizomes were much shorter and no vegetative propagation of ramets was observed.

The Flowering Stem. New flowering stems were not observed to develop after the first of July in any year. In 1975 there was a marked drop in total number of flowering stems in the three populations although there was no significant decrease in overall plant numbers or total leaf area produced.

The stems, which are hollow from the caudex to the base of the inflorescence, are easily broken during the first month or two of growth while they are green and tender. Much damage to plants occurs from animal activity, storms, and human interference. Of a total of sixty-two stems initiated in 1975 (the three populations combined) twenty three (37%) were completely broken off before fruits were produced.

The flowering stem may arise from within the center of a basal rosette of leaves or from a lateral offset of the caudex. Of one group of 27 flowering stems, sixteen had no basal leaves, five arose from a basal rosette, and six were associated with offset leaves. It is usually not obvious, without excavation, whether offset leaves are produced by an adjacent caudex or the same one from which the flowering stem arises.

A typical flowering stem of *Cacalia atriplicifolia* is shown in Fig. 4. Cauline leaves in general are more strongly dentate and lobed than are radical leaves and become progressively shorter-petioled and smaller toward the inflorescence (Fig. 5). Close to the inflorescence they become bractiate, 1–3 cm long and oblong in shape. The cauline leaves are often ascending, a characteristic which, together with those mentioned before, probably allows better penetration of light to lower parts of the plant (Horne 1972).

Size of the flower heads (6–11 mm) varies from one plant to another but is quite consistent within the same inflorescence. The flowers in an individual head bloom for about seven days. Only a few clusters on any particular plant actually have flowers open at any one time, and an entire inflorescence often produces flowers over a period of a month or longer. A slight, but readily discernible, delicate, pleasant fragrance is produced by the flowers. Pollen grains are sticky and adhere to other plant structures, dissecting instruments, and insect legs. The flowers show all the characteristics exhibited by insect pollinated flowers. Although formal pollination studies are the topic of a future paper, and not repeated here, several insect visitors were observed to carry pollen away on various parts of their bodies.

Table 2 presents data on flowering stem production including dimensions and number of flowering heads at the three sites over three years. Table 3 indicates correlations between stem height, basal diameter of stem, and number of flowering heads. Significant correlation exists between stem height and basal diameter, stem height and number of flowering heads, and basal diameter and number of flowering heads.

Chang (1968) concluded from a cytological study that apomixis is a characteristic of the breeding system of *C. atriplicifolia*. This was investigated in

Fig. 4. Flowering stem of *Cacalia atriplicifolia* showing growth habit, cauline leaves, and flower buds.

TABLE 2. Means of Stem Heights, Basal Diameter, and Number of flowering heads of *Cacalia atriplicifolia* in all sites. Numbers in parentheses are standard deviations.

	No. Observations	Height $\overline{X}$	Basal Diameter $\overline{X}$	No. Heads $\overline{X}$
1973	29	145.69	1.19	131.8
		(36.53)	(.53)	(109.75)
1974	21	109.76	.92	97.09
		(28.27)	(.36)	(64.97)
1975	32	119.9	.96	139.97
		(24.12)	(.51)	(47.19)
TOTAL	82	126.43	1.03	126.11
		(33.21)	(.49)	(79.78)

Fig. 5. Variations in leaf shapes in *Cacalia atriplicifolia*. E-F-G-H are radical leaves from one rosette. A-B-C-D are cauline leaves. The smaller ones are closer to the inflorescence.

the field in Site II and III. In 1975 the entire inflorescences of five flowering stems were bagged and observed throughout the flowering period. The flowering process appeared to develop normally. All the ovules produced in these five plants were counted (280 heads, 1400 flowers). No mature fruits were observed. In 1978 the investigation was repeated at Site III. Six inflorescences were bagged. Again all of the ovules produced were counted. From a total of 3,221 ovules, 3,217 did not develop into mature fruits but four apparently mature fruits were observed. Since the bags were tied rather loosely to avoid stress to the

TABLE 3. Correlation of Stem Height and Basal Diameter and Number of Flowering Heads in *Cacalia atriplicifolia* in all sites. (*indicates significance at the 0.01 level; **indicates significance at the 0.05 level)

1973		
	Height	No. of Heads
No. Heads	.43**	—
Basal Diameter	.77*	.76*

1974		
	Height	No. of Heads
No. Heads	.62*	—
Basal Diameter	.37	.43**

1975		
	Height	No. of Heads
No. Heads	.47*	—
Basal Diameter	.69*	.48*

1973–75 Combined		
	Height	No. of Heads
No. Heads	.46**	—
Basal Diameter	.68**	.58*

plants, it is possible that some pollen gained access through the neck of the one bagged inflorescence in which any mature fruits were found. Results of these investigations indicate conclusively that these populations are dependent upon outcrossing for seed production and are not apomictic under normal circumstances.

Achene Maturation. Achene maturation requires about three weeks. During this time the involucre is tightly adpressed but significant enlargement of the base of the head is perceptible. When the achenes are mature the involucre reflects, exposing the achenes which are then wind disseminated. Since the flowering period is prolonged by selective anthesis, achenes are released from August into November. Involucres exhibit considerable hydrochasy and open and close with lower and higher humidity respectively, thus optimizing fruit release times. Details of seed dispersal studies will be presented in Part II.

BIOTIC INTERACTIONS

Visitors & Possible Pollinators. Particular note was made of insect visitors to the *Cacalia atriplicifolia* flowers (Table 4) in an effort to determine potential and actual pollinators. Robertson (1928) reported that this plant was visited by short-tongued bees and other hymenopterans. A detailed study of pollination biology was not part of this study, but notes were made regarding insect visitors during approximately 70 hours of daylight observations in all three sites and in

TABLE 4. Insect Visitors and Possible Pollinators of *Cacalia atriplicifolia*

Insect Visitor	Degree of Frequency					
	A	B	C	D	E	F
Anoplius pompilidae (Spider wasps)				X		
Bombus sp. (Bumble bee)				X		
Chauliognathus pennsylvanicus (Soldier beetle)			X[2]			
Elis sp. (Tentative identification, Tuphiidae, parasitic wasp)		X				
Euchistus sp. (Shield bug)		X[3]				
Eumenes fraternus (Wasp)			X			
Limonia canadensis (Small cranefly)						X
Nicentrus sp. (Flower weevils)			X[1]			
Strymon sp. (Hairstreak butterfly)			X[1]			
Syrphus sp. (Flower flies or Hover flies)	X					
Tenthredo basilaris (Sawflies)					X	
Trichiotinus affinis tent. (Flower beetles)					X	

[1]Only during time that *Ceanothus americana* was in flower nearby.
[2]Only before anthesis of *Solidago spp*.
[3]On stems and flowers—possibly a pollinator as well as a predator.
Legend: A = very frequent; C = frequent; E = infrequent;
B = quite frequent; D = moderately frequent; F = occasional

garden plots from the initiation of the study to date. During this period, wasps of many species and syrphid flies were observed most frequently (Table 4). Also ten other species of hymenopterans as well as other unidentified dipterans were observed. No additional visitors were observed during the dusk and early evening hours and data on night-time visitors are still incomplete.

Other frequent or casual visitors included many species of ants and crab spiders. At times, almost every flower cluster on any one plant contained a crab spider and at least one ambush bug (*Phymata arosa*). The latter were often seen flying directly from one *C. atriplicifolia* inflorescence to another and this insect may be a pollinator of this plant.

Herbivory. Cacalia atriplicifolia is subject to attack by various herbivorous organisms. The flea beetle (Chrysomelidae) was the most frequently-observed predator. These insects ate small (to 1 mm) angular holes in the leaves. This damage was also evident in herbarium specimens of this plant from various areas of the United States, and occurred in all of the populations of the present study.

In mid- to late summer, grasshoppers, leaf hoppers, and various lepidopteran larvae were noted on the leaves and on the flowers. Large sections of leaves were completely destroyed in many instances. Leaf damage was also frequently caused by blotch- and serpentine leaf miners. Slugs caused considerable loss of tissue, especially in the seedling groups. This density-dependent predation was particularly devastating to seedlings because of their small total leaf area and lack of caudex tissue.

Powdery mildew caused considerable destruction, especially in 1973, when most of the above-ground portion of a considerable part of the Site II population was destroyed; all flowering stems and radical leaves of the sub-population had disappeared by mid-July. While some leaves were produced the following year, no flowering stems had been produced to the end of the study. Weather data compiled for the study period indicate that the Kalamazoo area received considerably above-normal precipitation in May and June of 1973 following abnormally warm temperatures in early May, which may have exacerbated the mildew problem.

Developing achenes of *C. atriplicifolia* were at times devastated by larvae of an unidentified Noctuid moth. The larvae, about 0.4 cm long when first noted on flower heads of all populations, reached a length of about 1.1 cm by September. These larvae chewed through the seed coat and destroyed the embryo. Typically, between 40%–80% of the potential achenes in a head develop. In 1973, 1974, and 1975 between 20% and 33% of the developing achenes in all three sites were destroyed. On a few plants essentially 100% of the achenes were destroyed. Flower heads were frequently webbed shut by larvae within a day or so following anthesis. Site III, which had the largest population of *C. atriplicifolia* plants, was most heavily infested by this predator. In 1974, at this site, in a random selection of fruits from three plants, 165 achenes of 448 (36.8%) were destroyed. In 1975 of fruits randomly chosen from heads of 8 plants, 284 out of 379 achenes (74.9%) were destroyed.

Competition. C. atriplicifolia did not appear to be a strong competitor in dense stands of grasses or trees, but flourished in more open, less shaded areas. Deam (1940) reported that he grew plants of *C. atriplicifolia, C. suaveolens,* and *C. muhlenbergii* at the edge of a bluegrass prairie for a period of several years. The plants of *C. atriplicifolia* and *C. muhlenbergii* gradually died out, while those of *C. suaveolens* extended the area of occupation about a foot each year. During this study, seedlings of *C. atriplicifolia* grown in fairly well-established bluegrass sod in a partially shaded location gradually died out. In areas where dense plant growth of other species cut light intensity to less than 50 foot candles, *C. atriplicifolia* seedlings did not survive well.

An interesting interrelationship with *Juglans nigra* (black walnut) was observed. At Site III, in 1975, flowering stems of *C. atriplicifolia* and *J. nigra* trees in each of 15 100 m^2 quadrats were counted. Eighty-two walnut trees were found to coexist with 51 flowering stems of *C. atriplicifolia*. Using 14 of 15 quadrats, a presence correlation of .9033 (highly significant at .01) was calculated. Seedling swarms of *C. atriplicifolia* were readily observed directly under the spread of these trees, and mature plants did well in these locations. It

is possible that a tolerance for juglone made colonization of this area more possible for *C. atriplicifolia* than for many other plants.

SUMMARY

Spread of populations of *C. atriplicifolia* appears limited in part by seedling vulnerability to climatic extremes, by predation, and by competition pressures. Seedling development is slow. Vegetative production of new plants is an important aspect of the overall life pattern, allowing expansion of populations over adjacent areas under favorable conditions. The plasticity of the species enables it to survive a wide range of temperature, light incidence, moisture, and edaphic influences.

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"MINI-COURSES" IN NATURAL HISTORY OFFERED AT THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION
June 14–18, 1987

Several years ago the University of Michigan Biological Station began offering special mini-courses designed for UMBS alumni. The courses are taught by Biological Station instructors who are top notch in their discipline, well acquainted with the northern Michigan region and are excellent teachers. This year the Station is opening these courses to others. The four courses offered this June are:

Flora of Northern Michigan will be offered by Professor Ed Voss of the University of Michigan Herbarium and *the* expert on the flora of the Great Lakes region and Michigan. Ed has taught the nationally renowned course *Boreal Flora* at UMBS for 19 years. His teaching is excellent and his style unique. Mid-June is an optimum season to study flowers in that region.

Nature Photography and Gary Williams are synonymous at UMBS. He has taught an exciting and popular course *Photography for Field Biologists* for years at the Station and has almost a quarter century of photographic experience in the region. Gary has won numerous awards for teaching excellence both in biology and photography.

Aquatic Biology will be taught again by Rex Lowe, Professor of Biology at Bowling Green State University and a 24 year veteran at UMBS. Rex has that special ability to make difficult topics fascinating and fun. His regular algae courses are legendary at UMBS.

Birds of Northern Michigan has been taught by Tom Van't Hof since we began offering mini-courses. Students from the previous years are unanimous in their praise of Tom's expertise and devotion to the course. Northern Michigan in mid-June has an especially rich diversity of bird life and Tom makes sure the class has an opportunity to visit all the important sites.

Approximate costs of five *full* 10 hour days (including field trips) of instruction, housing, meals, and laboratory and transportation fees is a modest $225.00.

If you wish to learn more about these courses created especially for people with strong interest in biology and natural history, write: Mark Paddock, The University of Michigan Biological Station, 2043 Natural Science Building, Ann Arbor, MI 48109-1048 or phone (313) 763-4461.

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WARREN WOODS AS FOREST PRIMEVAL: A COMPARISON OF FOREST COMPOSITION WITH PRESETTLEMENT BEECH-SUGAR MAPLE FORESTS OF BERRIEN COUNTY, MICHIGAN

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Warren Woods is possibly the best example of the mature beech-sugar maple forests of southern Michigan, or even in the midwestern and eastern United States (see Braun 1950), and certainly appears to be among the least-disturbed of forests of this type. The stand is part of a 120 ha state nature study area and consists of approximately 15.5 ha in the NW ¼, Sec. 27 of Chikaming Township, R20W, T7S, in Berrien County, Michigan.

The forest is located on till plain between a series of two lake-border moraines associated with the southeastern shore of Lake Michigan (Burgh 1939). Soils in the study area are mostly Selfridge loamy sands, although some Blount loam and Pewamo slit loam soils are included (Larson 1980); the first two series are somewhat poorly drained, and the last is a poorly drained soil found in depressions. The stand is bordered on the south and east by the Galien River, with associated floodplain forest and steep sandy banks, and by an agricultural field on the west and a two-lane paved road on the north (Fig. 1).

Warren Woods has a reputation as a virgin stand of beech-maple forest. Brewer (1980) has reviewed some of the evidence available regarding the disturbance history of the woods and confirms that it has never been logged, burned over, or grazed. He refers to the limited selective cutting alluded to by Cain (1935) during the period 1885–1890, but does not clearly indicate the extent of the disturbance.

According to a local resident interviewed by Cain (1935), an estimated ten percent of the timber was taken, although no beech (*Fagus grandifolia* Ehrh.) and little sugar maple (*Acer saccharum* Marsh.) were cut. Trees removed included basswood (*Tilia americana* L.), yellow-poplar (*Liriodendron tulipifera* L.), white oak (*Quercus alba* L.), and black cherry (*Prunus serotina* Ehrh.). Dice (1920) also noted that ''. . . a number of trees have been cut out in former years, and although no trees are now being cut down, all the trees and branches which fall are being cut up for firewood.'' The removal of fallen wood for firewood ended when the tract was transferred to the Parks Division of the Michigan Department of Natural Resources in 1949.

With the exception of the loss of American elm (*Ulmus americana* L.), which in 1933 represented 2.2% of all stems >1 in (2.5 cm) dbh (Cain 1935), and the very limited removal of other species from the stand, Warren Woods serves as an excellent representative of relatively undisturbed beech-maple forest. For this reason, the forest has been the subject of numerous ecological
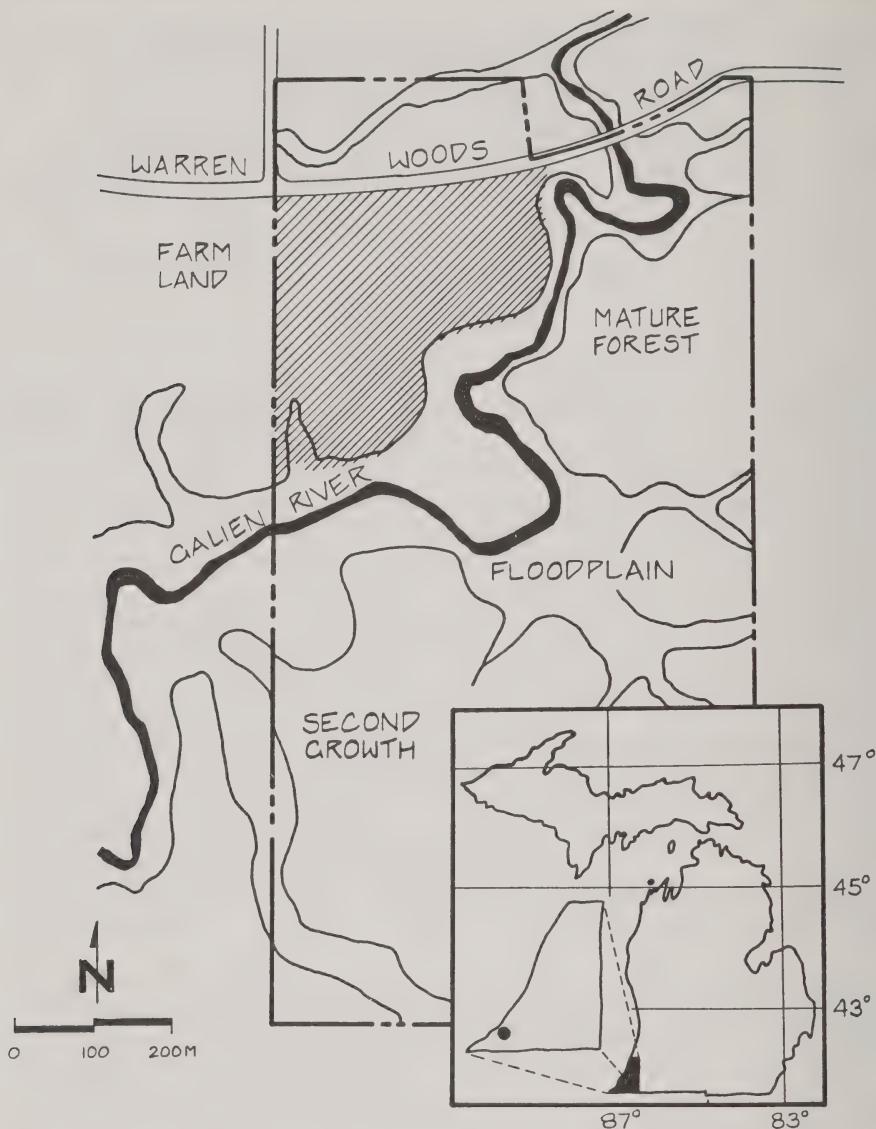
Fig. 1. Warren Woods Nature Study Area. General location of study site is indicated by hatched lines, and is bounded by the Galien River floodplain, an agricultural field, and Warren Woods Road. Adapted from Warren Woods Master Development Plan, Michigan Department of Natural Resources, Parks Division, 1970.

investigations and publications (Dice 1920, Cain 1935, Braun 1950, Lindsey & Escobar 1976, Fox 1977, Brewer & Merritt 1978, Woods 1979, Brewer 1980, Rogers 1981, Woods & Whittaker 1981, Donnelly 1986).

As part of on-going investigations of the natural processes which determine

and maintain forest composition in Warren Woods, we set out to determine the degree of similarity between the forest composition of Warren Woods and presettlement beech-maple forests of Berrien County, Michigan.

MATERIALS AND METHODS

Overall forest composition of Warren Woods was studied in 25, 100 m² (10 × 10 m) plots. These plots were located throughout the study area by using random numbers corresponding to compass sight-line directions and distances along the lines. The minimum allowable distance between plots was 20 m. Plots with borders falling within 25 m of any forest edge were rejected. All stems ≥2.5 cm diameter at breast height (dbh) were identified and their dbh measured with a steel tape. From these data, values for density, dominance (in terms of basal area), and frequency were derived for each species and importance values were calculated from them (Curtis & McIntosh 1951). The importance value (IV) of a species is defined as the sum of relative density, relative dominance, and relative frequency. Importance values were converted into importance percentages by dividing each IV by three.

Composition of the presettlement beech-maple forest of Berrien County was derived from data contained in the General Land Office survey of Michigan, conducted during the period 1825–1832. Data were kindly made available to us by L. G. Brewer, T. W. Hodler, and H. A. Raup, who had transcribed information contained in the surveyor's original field notes onto topographic maps. They used these data to construct a detailed map of the presettlement vegetation of southwestern Michigan (Brewer et al 1984). The original field notes are on file in the Lands Division of the Michigan Department of Natural Resources in Lansing, Michigan.

Brewer et al (1984) delineated vegetation boundaries in ten counties, including Berrien, from witness and line trees and from slope contours on U. S. Geological Survey topographic maps. Methods used to distinguish adjacent categories of different vegetation are contained in Brewer et al. (1984). They indicated that their boundaries between beech-maple forest and northern coniferous-hardwood forest were accurate to ±½ mi (0.8 km); boundaries between beech-maple and oak forests were accurate to ±¼ mi (0.4 km).

Relative values for density, dominance (basal area), and frequency were computed for all tree species included within areas of Berrien County designated as beech-maple forest by Brewer et al (1984). Their topographic maps, with tree data, and map overlays, which delineated different vegetation categories, were used in the analysis. Only the species of the witness and line trees, and their diameters, were recorded on the topographic maps; line-to-tree distances were not recorded. Accordingly, only relative values for tree species could be determined.

The total number of trees of each species was divided by the total number of all trees to determine values for relative density. Relative dominance was calculated from the basal area total for each species, which was expressed as a percentage of the total for all species combined. Frequency values were derived from section corner trees only. A total of 47 section corners having four witness trees was contained within beech-maple forest areas of Berrien County. Frequency for a species was calculated as the number of corners, in percent, at which that species was present among the four trees. Relative frequency value for a species was computed as the percentage of the sum of the frequency values for all species that was attributed to that particular species. Importance values and importance percentages were calculated as before for the Warren Woods data.

RESULTS

In present-day Warren Woods, beech and sugar maple greatly exceeded all other species measured in density, in basal area dominance, and in frequency (Table 1). Together, these two species accounted for over 86% of the total importance for all species. All other species had importance percentages of 4.3 or less. The other species included, in order of importance, ironwood or blue-beech (*Carpinus caroliniana* Walt.), basswood, yellow-poplar, hop-

TABLE 1. Forest composition of Warren Woods[*].

Species	Relative Density	Relative Dominance (Basal Area)	Relative Frequency	Importance Value[**]	Importance Percentage
Fagus grandifolia	43.8	68.2	38.6	150.6	50.1
Acer saccharum	47.6	20.0	40.4	108.0	36.0
Carpinus caroliniana	3.8	0.2	8.8	12.8	4.3
Tilia americana	0.5	6.3	1.8	8.6	2.9
Liriodendron tulipifera	0.5	5.3	1.8	7.6	2.5
Ostrya virginiana	1.4	0.0	3.5	4.9	1.6
Ulmus americana	1.4	0.0	1.8	3.2	1.1
Lindera benzoin	0.5	0.0	1.8	2.3	0.8
Hamamelis virginiana	0.5	0.0	1.8	2.3	0.8
TOTALS	100.0	100.0	100.3	300.0	100.1

[*]Trees and shrubs ≥2.5 cm dbh. Total area sampled, 2500 m^2.
[**]Importance value = relative density + relative dominance + relative frequency.

hornbeam (*Ostrya virginiana* (Mill.) K. Koch), American elm, spicebush (*Lindera benzoin* (L.) Blume), and witch-hazel (*Hamamelis virginiana* L.).

Trees and shrubs present in low numbers in Warren Woods, but not found within the 2500 m^2 sampling area, included: red maple (*Acer rubrum* L.), pawpaw (*Asimina triloba* (L.) Dunal), bitternut hickory (*Carya cordiformis* (Wang.) K. Koch), shagbark hickory (*Carya ovata* (Mill.) K. Koch), white ash (*Fraxinus americana* L.), sycamore (*Platanus occidentalis* L.), black cherry, white oak, red oak (*Quercus rubra* L.) red-berried elder (*Sambucus pubens* Michx.), and mapleleaf viburnum (*Viburnum acerifolium* L.).

Beech (IV% = 50.1; Table 1) was more important in Warren Woods than sugar maple (IV% = 36.0), primarily because of the dominance by beech in the canopy layer. The ratio of beech dominance to that of sugar maple was 3.4. The ratio in density of trees ≥20 cm dbh of beech to sugar maple was 2.8. Among all stems ≥2.5 cm dbh, however, sugar maple relative density (47.6) and relative frequency (40.4) were higher than for beech (43.8 and 38.6, respectively). With beech more important in the canopy, the higher values of density and frequency for sugar maple indicated the abundance of sugar maple regeneration in the understory.

The composition of beech-maple forests of Berrien County at the time of the original land survey is shown in Table 2. Beech clearly dominated over all other species in the original forests, with an importance percentage of 47.3. Beech had values for relative density, dominance, and frequency that were at least twice those of sugar maple, which was second in importance in all categories. Sugar maple appeared to be less important relative to beech in the original forests than in Warren Woods; the ratio in relative dominance of beech to sugar maple in presettlement times was 4.5. The ratio of beech to maple was 4.9 for all stems ≥8 cm dbh and 4.7 for trees ≥20 cm dbh.

A total of 18 tree species having an importance percentage ≥0.1 were recorded in the original forests, compared with the nine woody species measured

TABLE 2. Composition of presettlement beech-maple forests of Berrien County, Michigan.

Species	Relative Density	Relative Dominance (Basal Area)	Relative Frequency	Importance Value[*]	Importance Percentage
Fagus grandifolia	53.5	45.2	43.3	142.0	47.3
Acer saccharum	11.1	10.1	18.4	39.6	13.2
Tilia americana	8.7	9.9	7.8	26.4	8.8
Fraxinus sp.	6.5	6.7	12.0	25.2	8.4
Ulmus americana	5.3	5.7	5.1	16.1	5.4
Quercus alba	2.3	4.9	5.1	12.3	4.1
Liriodendron tulipifera	2.4	5.8	0.9	9.1	3.0
Populus sp.	2.9	4.1	1.8	8.8	2.9
Ostrya virginiana	2.0	0.4	1.8	4.2	1.4
Quercus rubra	0.9	1.5	1.8	4.2	1.4
Prunus serotina	0.8	0.4	0.9	2.1	0.7
Carya sp.	1.1	0.8	0.0	1.9	0.6
Juglans nigra	0.4	0.5	0.9	1.8	0.6
Acer rubrum	0.6	0.5	0.0	1.1	0.4
Quercus velutina	0.3	0.4	0.0	0.7	0.2
Tsuga canadensis	0.3	0.3	0.0	0.6	0.2
Juglans cinerea	0.2	0.1	0.0	0.3	0.1
Quercus macrocarpa	0.1	0.1	0.0	0.2	0.1
TOTALS	100.2	100.1	99.8	300.0	98.8

[*]Importance value = relative density + relative dominance + relative frequency.

in Warren Woods. The understory tree, ironwood, and the shrubs, spicebush and witch-hazel, were recorded in the Warren Woods survey, but were not included among the trees used or found by the surveyors.

Tree species of the presettlement forests that are not present in Warren Woods included: poplars (*Populus*), black walnut (*Juglans nigra* L.), black oak (*Quercus velutina* Lam.), hemlock (*Tsuga canadensis* (L.) Carr.) butternut (*Juglans cinerea* L.) and bur oak (*Quercus macrocarpa* Michx.).

DISCUSSION

Warren Woods serves as an excellent model of natural beech-maple forest. The strong dominance of beech and sugar maple over all other species in this stand (Table 1) is typical for the forest type in the mature state (Braun 1950, Lindsey & Escobar 1976). Further, the much greater abundance of beech in the overstory and of sugar maple in small size classes has characterized other old-growth remnants of beech-maple forest throughout its range (Esten 1932, Morey 1936, Hough & Forbes 1943, Braun 1950, Petty & Lindsey 1961, Vankat et al 1975, Abrell & Jackson 1977, Gilbert & Riemenschneider 1980, Rogers 1981). The ratio of the number of beech to sugar maple trees in the overstory in Warren Woods (2.8) is within the range of 1.5 to 3.1 reported for these other remnant stands. The relative rarity of the other associated species in Warren Woods, such as yellow-poplar and black cherry, is also similar to that observed in other mature beech-

maple stands (Potzger & Friesner 1943, Hough & Forbes 1943, Braun 1950, Potzger 1950, Petty & Lindsey 1961, Beals & Cope 1964, Jackson & Allen 1968, Vankat et al 1975, Abrell & Jackson 1977, Gilbert & Riemenschneider 1980).

These compositional characteristics for present-day Warren Woods are also similar to those of presettlement beech-maple forests. The original forests of Berrien County (Table 2) and of other areas in Indiana, Ohio, and Pennsylvania were also dominated by beech and sugar maple (Blewett & Potzger 1950, Potzger & Potzger 1950, Ross 1950, Shanks 1953, Goodlett 1954, Potzger et al 1957, Lindsey et al 1965, Whitney 1982). Beech was consistently more abundant than sugar maple in these presettlement forests, where the ratio in density of beech to sugar maple trees ($\sim \geq 8$ cm dbh) ranged from 2.5 to 5.9.

The apparently greater importance of beech over maple in presettlement forests relative to modern forests (Tables 1 and 2) has led some investigators to suggest that a successional shift in importance has taken place since the time of settlement (Ward 1956, Beals & Cope 1964). While changes in the importance of these two species may have occurred, factors other than successional mechanisms may have contributed to the apparent difference.

Beech trees may be accorded greater importance than sugar maple in the surveyor's data because they did not record trees as small as those included in current ecological studies. Surveyors were sometimes instructed to measure only trees that were ≥ 5 in (~ 10 cm) diameter, although smaller trees were occasionally recorded (Bourdo 1956, and this study). Trees as small as 2.5 cm dbh, and sometimes 1.0 cm dbh, are commonly included in current sampling procedures. It is in these small size classes that the importance of sugar maple is elevated because of the density and frequency of occurrence of small sugar maple saplings in the understory.

Beech may also have been over-represented in the presettlement data because of surveyor's bias in favor of beech. Bourdo (1956) has reviewed the importance of bias in the survey data to the interpretation of presettlement forest composition. He suggested that beech may have been preferred by surveyors because its smooth bark did not need to be blazed to provide a surface for their iron marks. Beech may also have been selected because it was of little timber value at the time and because its smooth ashy-gray bark made it conspicuous for relocation (Gordon 1969). Although bias was undoubtedly present, it probably is not of major consequence, since the range in species at any one sampling point was limited (Bourdo 1956).

Beyond the probable range of surveyor's bias, it is reasonable to assume that beech was more important than sugar maple in the forests of presettlement times, just as it is in present-day Warren Woods. It is also likely that the relative rarity of yellow-poplar and black cherry in Warren Woods (Table 1) and in other remnant stands reflects their natural rarity in presettlement times. Yellow-poplar and black cherry were rare in the presettlement beech-maple forests of Berrien County (Table 2) and of other areas for which survey data have been analyzed (Blewett & Potzger 1950, Potzger & Potzger 1950, Ross 1950, Shanks 1953, Goodlett 1954, Lindsey et al 1965, Whitney 1982).

Overstory composition of present-day Warren Woods, therefore, is similar to other remnant beech-maple forests and to those that existed prior to settlement,

at least in the relative proportion of the dominants and the rarity of shade-intolerant associates. This stand then represents a realistic model for the study of primeval beech-maple forest, and its composition likely reflects the result of natural forest processes which operated in presettlement times.

ACKNOWLEDGMENTS

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A LITTER INTERCEPT METHOD FOR DETERMINING LEAF AREA INDEX IN DECIDUOUS FORESTS

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Leaf area is an important parameter of forest ecosystems. It has been directly related to forest productive capacity (Waring 1983) and is usually reported as the ratio of the area of leaf surface supported over the area of ground surface. This measure is termed the leaf area index and has units of m^2/m^2. Many different methods have been devised in attempts to find an easy way to measure leaf area index. These include use of leaf weight:area ratios and optical density (Odum, et al 1963), point-quadrat sampling methods (Wilson 1965, MacArthur & Horn 1969, Aber 1979), spectral quality of light reaching the forest floor (Jordan 1969), comparison with standard leaf images of known area (Heller 1971), and cross-sectional area of sapwood (Waring, et al 1977) among other approaches. Brief reviews of methods are given by Newbould (1967) and Marshall (1968).

The purpose of this paper is to describe and test a method for measuring leaf area index in forests with distinctly seasonal leaf fall. The method, termed the litter intercept method, is a modification of a canopy leaf intercept method (Jordan 1969). In the intercept method a line is passed through a canopy, usually a plumb line extended from a tower, and the number of points where the line touches a leaf equals the leaf area index. In our modification we wait for the leaves to drop to the forest floor and then determine the leaf area index by pushing a nail through the leaf litter. The nail is analogous to the plumb line and the number of leaves that the nail passes through equals the leaf area index. The approach is based on the assumption that when leaves fall from the canopy they create a layer of litter on the ground equal in thickness to the layer of leaves previously in the canopy. This condition holds only for those forests which drop their leaves completely and over a short period of time.

The litter intercept method is tested here with a comparison against a harvest method, in which trees are destructively sampled, for measuring leaf area index. In the harvest method leaf area index is calculated for individual trees by dividing an estimate of canopy area projected on the ground into an estimate of the area of leaves in the canopy.

METHODS

Measurements were made in a young, even-aged stand of red maple (*Acer rubrum* L.) located in Geauga Co., northeastern Ohio (Troy Township, Section 17, T6N, R7W). The stand has developed on a fallow agricultural field and probably originated following one or a few good seed years. The average diameter of trees in the stand is 8.2 cm.

Measurements by the harvest technique were made in July 1982 after the leaves were fully expanded. Six trees were chosen for harvest in different sections of the stand and their canopy areas were marked out with stakes below the margin of the canopy on the ground. A tape was then

TABLE 1. Leaf area index and tree attributes of a red maple stand, Geauga Co., Ohio determined by destructive sampling.

Tree Number	DBH cm	Height m	Canopy Area m²	Number of Leaves	Average Leaf Size[1] cm²	Leaf Area Index m²/m²
1	6.9	7.0	2.6	2,778	37.42	4.0
2	10.7	9.5	6.9	10,835	36.39	5.7
3	6.5	5.2	2.0	5,644	34.07	9.6
4	6.1	9.0	1.2	2,891	31.49	7.6
5	4.8	7.5	1.0	2,832	34.00	9.6
6	9.4	8.5	4.0	6,321	38.20	6.0

[1]Based on a sample of 20 leaves from each tree.

stretched around the stakes to measure the length of the canopy perimeter. The canopy area was approximately a circle, and the area was calculated based on the perimeter dimension. The trees were cut down and all the leaves on each tree were counted. For each tree all the leaves were mixed in large bags and 20 leaves were removed from the bags at random. Leaf area was measured with a planimeter for each of these leaves. No correction was made for leaf holes within the margin of the leaves. From this subsample the average area per leaf was calculated which when multiplied by the total number of leaves gave the total leaf area for each tree. The leaf area index was found by dividing the leaf area by the canopy area projection on the ground. Characteristics of the six trees used in the harvest method are given in Table 1.

Sampling by the litter intercept method was conducted in November 1982 after all the leaves had fallen to the forest floor. Transect lines were extended along the forest floor from randomized starting points, and measurements were made every meter along the lines. No measurements were made within five meters of the edge of the stand or of one of the gaps where trees were harvested in July. At each point along the transect a nail (6½ cm long box nail) was pushed through the leaf litter. The freshly fallen leaves, termed O_i litter, were carefully pulled away from the nail to make an accurate count of the number of intercepts per point. Only recently fallen leaves of the current year were counted. Counts were made at a total of 90 points along the transect lines.

RESULTS AND DISCUSSION

The mean leaf area index for the six destructively sampled trees was 7.1 ± 0.9 (S.E.), range 4.0–9.6 (Table 1). In the litter intercept technique the range of leaf area index was from 3 to 13 with a mean value of 6.8 ± 0.2 (S.E.). The means of the leaf area index by the two techniques are not statistically different (t-test, $p < 0.01$). Both estimates are within the range of leaf area for temperate deciduous forests reported by Lieth (1975) but are larger than the mean value of 5 given by Whittaker & Likens (1975).

One of us (HHC) has used the litter intercept method as a class exercise in a general ecology course starting in the late 1960's. Table 2 lists a sample time series of leaf area index data determined by the litter intercept method in a mixed oak-hickory forest in Washtenaw Co., southeastern Michigan. Leaves were identified as they were pulled away from the nail in these studies allowing data to be recorded by species. The similarity of total leaf area index values for the three years indicates the relative reproducibility of the method. The leaf area index values for the Michigan oak-hickory forest are lower than the values from the Ohio red maple forest described earlier. The maple forest is a young stand on

TABLE 2. Leaf area index data over a three year period from Loesell Field Lab Woods, Washtenaw Co., Michigan. Units are m^2 of leaf surface area per m^2 of ground area. Means are for approximately 300 points each year.[1]

Species	Year of Sample		
	1968	1969	1970
Red Oak, *Quercus rubra* L.	2.98	3.06	2.72
White Oak, *Quercus alba* L.	0.37	0.44	0.40
Black Cherry, *Prunus serotina* Ehrh.	0.35	0.38	0.26
Red Maple, *Acer rubrum* L.	0.09	0.20	0.14
Hickory, *Carya* spp.	0.07	0.10	0.15
other species	0.10	0.14	0.26
Total	3.96	4.32	3.93

[1]Sampling was conducted on relatively flat topography during the fall season.

a mesic site and may have a higher net primary productivity than the older, more mature oak-hickory forest.

In our evaluation the short-cut litter intercept method gave results not significantly different from a more conventional harvest method. The litter intercept method is easier and faster than other techniques and requires no special equipment. However, the present use of the method is limited to forests with distinctly seasonal leaf fall. Another potential limitation of the method is movement of litter by wind. Uneven surfaces, such as mound and pit topography, may amplify this problem. For these reasons we suggest that sampling be conducted as soon as possible after leaf fall and that sample sizes be relatively large. Within the constraints listed above, the litter intercept method should be applicable to broadleaf, deciduous forests found throughout the temperate zone where low temperature in the fall limits the growing season and causes leaf drop. The method may also work in dry forests where seasonal drought is responsible for leaf fall.

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THE HANES FUND AND THE MICHIGAN FLORA PROJECT

The Hanes Fund was established in 1968 in accordance with the will of Florence N. Hanes

"to be used . . . for the publishing of a Flora of the State of Michigan or should the publishing of a Flora of the State of Michigan have been accomplished prior to my death, then I direct that . . . the fund . . (be utilized) . . for the further study of the local vascular plants . . ."

The fund is administered by three court-appointed Trustees who, currently, are Harriette Bartoo (Kalamazoo), W. H. Wagner (University of Michigan) and William J. Gilbert (Albion College).

The cost of publication of the first and second volumes of MICHIGAN FLORA (part I, Gymnosperms and Monocots and part II, Dicots) was underwritten by the Hanes Fund. It is anticipated that at least part of the cost of volume III also will be underwritten.

In the meantime, the Trustees of the Hanes Fund announce the availability of small grants for incidental expenses in connection with well-planned projects that will make a definite contribution to the Michigan Flora Project. Maximum size of the grants will be $500 with the average grant between $200 and $300. Supported projects must deal with the vascular plants of Michigan. First sets of collected plants must be deposited at the Herbarium of the University of Michigan. Amateur and professional botanists, as well as advanced college students, are eligible to apply for the grants.

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A FLORISTIC SURVEY OF BUTTONBUSH SWAMPS IN GAHANNA WOODS STATE NATURE PRESERVE FRANKLIN COUNTY, OHIO

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Buttonbush, *Cephalanthus occidentalis* L. (Rubiaceae), is a wetland shrub which occurs in most Ohio counties (Hauser 1964). It is a conspicuous floristic element in sites within the swamp forests of Gahanna Woods State Nature Preserve (Franklin County). These sites, which are flooded much of the year, have been classified as "buttonbush shrub swamps" according to a preliminary list of Ohio plant communities (Anonymous 1982), although the question of whether to interpret the buttonbush swamp as a distinct plant community in central Ohio has not been fully resolved.

This study was initiated to gather floristic information about buttonbush swamps in central Ohio in order to answer three basic questions: (1) Is the number of species present in a buttonbush swamp a function of the area of the swamp? (2) How similar floristically are different buttonbush swamps? (3) Are there any species frequently found only in association with buttonbush, such that these species might be considered as much indicator species of the buttonbush swamp community as buttonbush itself?

DESCRIPTION OF STUDY AREA

Gahanna Woods, a 20.2 ha state nature preserve in eastern Franklin County, Ohio, includes several plant communities. A dominant feature of the preserve is the low-lying, seasonally flooded swamp forest of *Acer saccharinum* (silver maple), *Acer rubrum* (red maple), *Quercus palustris* (pin oak), with *Fraxinus* (ash) and *Ulmus* (elm) species also present. The buttonbush swamps, or "woodland ponds" (Division of Natural Areas and Preserves unpub.), are conspicuous areas within the swamp forest. They are characterized by an absence of living trees, although snags or stumps may be present, several to many buttonbush shrubs, and standing water at some time during the year. There are seven buttonbush swamps in the preserve, five of which lie in a linear chain. The floristic composition of six of the swamps was surveyed (sites I–VI, Fig. 1). Although all the swamp sites lacked standing water during October, 1984, the topography of the terrain is such that sites I–IV are connected by water when water levels are high in the winter (Fig. 1). Site VI is the only site with Pewamo soils (silty, clay loam); the soil type of the other sites is Carlisle muck (U.S. Department of Agriculture 1980).

METHODS

The length and width of these six buttonbush swamp sites were measured directly in the field (sites I–IV, VI) or estimated from aerial photos (site V) (U.S. Department of Agriculture 1980). For
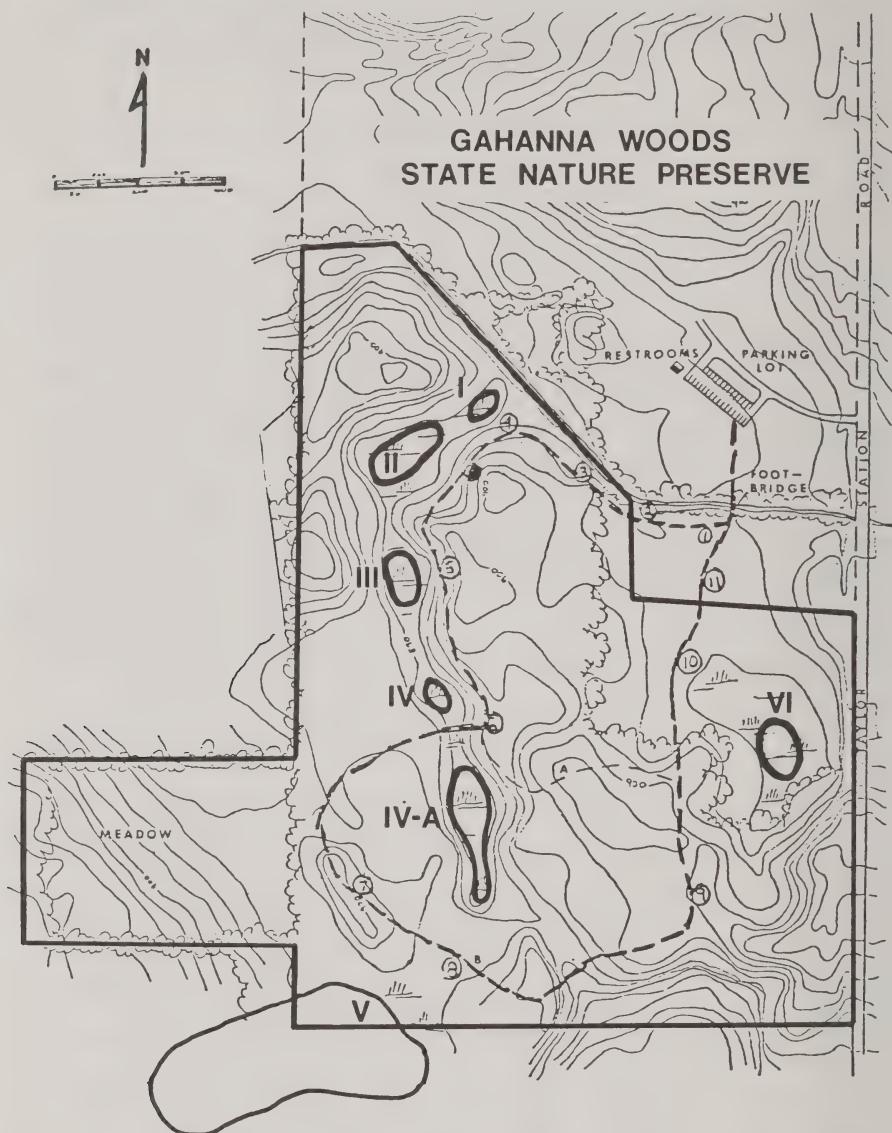
Fig. 1. Location of buttonbush swamp sites (I–VI) in Gahanna Woods State Nature Preserve, Franklin County, Ohio. All sites were surveyed except IV–A. Entire bar of map scale equals 122 m (400 ft.)

each site, the number of buttonbush shrubs was estimated and their distribution relative to the site boundaries was recorded. Maximum water depth was recorded for sites I–IV at intervals during October and November, 1984. Rainfall data for these same months were obtained from records kept at Blacklick Woods Metro Park, located 10 km SE of Gahanna Woods.

Each site was visited at least three times during late October and November, 1984. A list was compiled of all flowering plant species encountered during these visits while walking around the

perimeter and in zig-zag patterns through each site. Permanent collections (indicated "c" in Table 1) were made of certain plants to aid in species identification. The vouchers were deposited in the herbarium of The Ohio State University (OS). The similarity in species composition among sites was compared by the index of similarity, I.S. = 2w/a + b, where "w" is the number of species two sites have in common, "a" is the number of species at one site, and "b" is the species number at the second site (Curtis 1959). In order to quantify the degree of site similarity in another way, an index of homogeneity was calculated: I.H. = $\Sigma P_i / \Sigma T_i$, where "P_i" is the number of prevalent species found at site i, and "T_i" is the total number of species found at site i summed over sites (after Curtis 1959). The methods of Curtis (1959) were used to determine how many species should be considered prevalent species. In this study, the prevalent species were those that were present at three or more sites.

RESULTS

The four sites in the linear chain range in length from 25 to 73 m (Table 2). Site V is the largest, with an approximate length of 180 m, and extends beyond the boundary of the preserve (Fig. 1). In addition to area differences, the six swamp sites differed in their general appearance with regard to the number and distribution of buttonbush shrubs (Tables 2, 3), which species were most conspicuous (Table 3), and the temporal pattern of standing water in the site (Table 3, Fig. 2).

Of the 52 species recorded in the six buttonbush swamp sites, 20 were additions to the Gahanna Woods flora prepared by Snodgrass & Stuckey (1976) (Table 1). The addition of *Carex decomposita* (cypress-knee sedge) was particularly noteworthy, as this species had been assumed extirpated from Ohio (Stuckey & Roberts 1982). The last record of *C. decomposita* in Ohio was from Buckeye Lake in 1910 (Braun 1967). This species was not included in a recent compilation of abstracts prepared about the endangered plants of Ohio (McCance & Burns 1984).

The number of species in the buttonbush swamp sites in Gahanna Woods ranged from 14 (site III) to 34 (site V) (Table 2). Species number was roughly associated with the area of the swamp (Fig. 3). The largest swamp site (V) did have the largest number of species (34); the smallest site (I), however, had an intermediate number of species (Table 2, Fig. 3).

The index of similarity values (one value generated for each pairwise comparison of buttonbush swamp sites) ranged from 0.39 to 0.74 (Table 4). The index of homogeneity (an indication of overall site-to-site variability within Gahanna Woods) was 0.75.

In addition to *Cephalanthus*, four species, *Boehmeria cylindrica* (false nettle), *Sium suave* (water-parsnip), *Scuttellaria lateriflora* (mad-dog skullcap), and *Bidens comosus* (bur-marigold), were present at all six sites (Table 1).

DISCUSSION

It is difficult to delimit precisely the boundaries for a given buttonbush swamp site at Gahanna Woods. A higher species richness in the buttonbush swamp community results from including species found at the periphery of the swamp sites. In this study, for sites I–IV, "wet woods" plants found exclusively

TABLE 1. Flowering plant species found in six buttonbush swamps at Gahanna Woods State Nature Preserve, Franklin County, Ohio (* indicates the species was not listed in the flora of Snodgrass and Stuckey (1976); c indicates a herbarium voucher specimen was collected; m indicates the species was found only at the swamp margin; x indicates presence at site).

	Sites					
	I	II	III	IV	V	VI
Typhaceae						
Typha latifolia L.					x	x
Alismataceae						
Alisma plantago-aquatica L. (c)					x	x
Gramineae						
*Cinna arundinacea L. (c)	m		m	m	x	
*Echinochloa crusgali (L.) Beauv. (c)				x		x
Glyceria striata (Lam.) Hitchc. (c)	m	m	m		x	
*Leersia oryzoides (L.) Swartz (c)				x	x	x
Panicum sp.				x		
Cyperaceae						
*Carex crinita Lam. (c)					x	x
*Carex decomposita Muhl. (c)					x	
*Carex frankii Kunth (c)						x
*Carex lupuliformis Sartwell (c)					x	
*Carex tribuloides Wahl, (c)	m	m	m		x	x
*Carex typhina Michx. (c)					x	
Carex vulpinoidea Michx. (c)						x
Carex sp. (A) (c)					x	
Carex sp. (B) (c)					x	
Carex sp. (C)	x	x	x		x	
Carex sp. (D)		x				
*Scirpus cyperinus (L.) Kunth						x
Lemnaceae						
Lemna minor L.					x	
Iridaceae						
*Iris sp. (c)					x	
Salicaceae						
Salix sp. (c)					x	
Populus deltoides						x
Urticaceae						
Boehmeria cylindrica (L.) Sw.	m	x	m	x	x	x
Pilea pumila (L.) Gray (c)	x	x				
Phytolaccaceae						
Phytolacca americana (L.) (c)				x		
Polygonaceae						
*Polygonum lapathifolium L. (c)		x				
*Polygonum pensylvanicum L. (c)		x			x	x
*Polygonum persicaria L. (c)	x	x	x		x	
*Polygonum punctatum Ell. (c)	x		x	x	x	
Rumex verticillata L. (c)	x	x		x	x	
Tovara virginiana (L.) Raf.	m					
Ranunculaceae						
Ranunculus flabellaris Raf. (c)		x				

TABLE 1. (*Continued*)

	I	II	III	IV	V	VI
			Sites			
Cruciferae						
Cardamine pensylvanica Muhl. (c)	x	x			x	
Rorippa sp. (c)		x				
Crassulaceae						
Penthorum sedoides L.						x
Saxifragaceae						
Ribes sp. (?)			x			
Rosaceae						
Geum sp.	m	m				x
Rosa sp.	m	m			x	
Euphorbiaceae						
Acalypha sp. (c)	x		x	x		
Balsaminaceae						
Impatiens sp.				x	x	
Onagraceae						
Epilobium coloratum Biehler (c)				m	x	x
Apiaceae						
Sium suave Walt (c)	x	x	x	x	x	x
Lamiaceae						
Lycopus rubellus Moench (c)		x		x	x	x
Scutellaria lateriflora L. (c)	m	m	x	x	x	x
Solenaceae						
Solanum dulcamara L. (c)				x	x	
Rubiaceae						
Cephalanthus occidentalis L.	x	x	x	x	x	x
Galium sp. (c)					x	
Asteraceae						
Aster sp.	m	m		m	x	x
Bidens comosus (Gray) Wieg. (c)	x	x	x	x	x	x
Bidens frondosus L. (c)	x	x	x		x	x
Xanthium sp. (?)	x			x		

at the margins of the buttonbush swamps (e.g., *Cinna, Geum,* and many *Carex* species) were distinguished from the remainder of the swamp site species (indicated as "m" and "x", respectively, Table 1). By including these "marginal" species, the number of species found at each site was increased substantially (19%–75%).

The addition of 20 species to the flora of Gahanna Woods State Nature Preserve (Snodgrass & Stuckey 1976) reflects the fact that this survey was made in the fall whereas their study was conducted in the spring and summer months. In addition, their study did not include an extensive search in the wetland areas, while this survey was restricted to the swamp sites.

The trend for larger buttonbush swamp sites to contain more species

TABLE 2. Swamp size (widest and longest dimensions, and approximate area), number of species, and number of buttonbush shrubs for six swamp sites surveyed in Gahanna Woods State Nature Preserve, Franklin County, Ohio. The area of each swamp site was calculated by multiplying the length and width dimensions, and thus is an estimate, since the shape of each site is elliptical or irregularly shaped rather than rectangular.

Site	Dimensions of Treeless Area (m)	Approximate Area (m^2)	Number of Species	Approximate Number of Buttonbush
I	17 × 25	425	21	> 15
II	38 × 69	2622	22	> 75
III	31 × 73	2263	14	< 10
IV	16 × 41	656	19	> 50
V	70 × 180	12600	34	>> 300
VI	31 × 48	1488	22	> 50

TABLE 3. Descriptive site information on vegetation, buttonbush shrub locations, and water regimes for the six buttonbush swamps surveyed in Gahanna Woods State Nature Preserve.

Site	Predominant vegetation	Location of buttonbush	Water regime (11 Nov 84)
I	*Sium* *Bidens* (on stumps) *Cephalanthus*	one side of central area	water extends to edge of buttonbush
II	*Polygonum* sp. mats of *Carex* sp. *Bidens* *Sium* (at one end)	margin of open area	water extends to edge of buttonbush
III	*Sium* (in center) *Bidens* (margin)	margin of open area	water present, does not extend to buttonbush
IV	*Cephalanthus* *Sium* *Bidens*	throughout	buttonbush in standing water
V	*Cephalanthus* *Carex decomposita* *Carex* sp. (margin)	throughout	buttonbush in standing water
VI	*Typha* (two clumps) vegetative grasses *Sium* *Leersia* *Cephalanthus* *Scirpus*	margin of open area, and at very center	some of the central buttonbush in standing water

generally fits the typical species-area curve (Fig. 3). In addition to size differences, the buttonbush swamp sites differ both with respect to distance from other sites and whether there are seasonal water connections with other sites (permitting transit of water-dispersed seeds between sites). Differences among sites based on soil type, water level regime, and the distribution of the

TABLE 4.   Index of similarity values for all pairwise comparisons of buttonbush swamp sites (I–VI) surveyed in Gahanna Woods State Nature Preserve. The numbers in parentheses beside the site numbers are the total number of species found at that site.

|	I	II	III	IV	V
I (21)					
II (22)	0.74				
III (14)	0.74	0.56			
IV (19)	0.55	0.39	0.42		
V (34)	0.57	0.57	0.42	0.49	
VI (22)	0.42	0.50	0.39	0.49	0.54
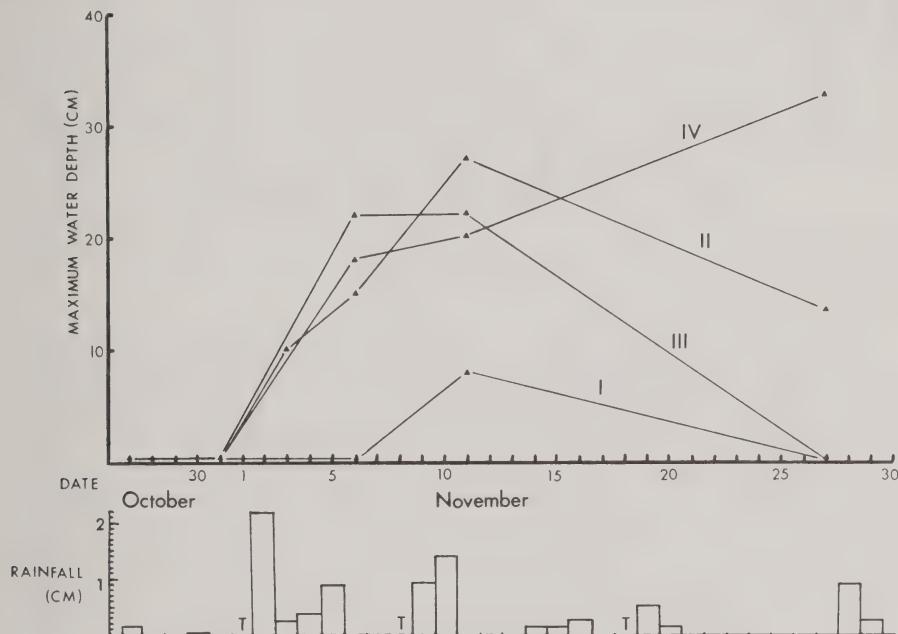
Fig. 2. Maximum depth of standing water for buttonbush swamp sites (I–IV) in Gahanna Woods State Nature Preserve during late October and November, 1984. Daily rainfall over this time period recorded at Blacklick Woods Metro Park is indicated on the time line below the x-axis.

buttonbush shrubs relative to the site margins also exist. If one of these factors strongly influences the species composition of a buttonbush swamp, then two sites that are more similar with respect to this factor would be expected to have a relatively higher index of similarity. However, none of these factors was consistently correlated with a consistently higher or lower index of similarity in pairwise comparisons of these swamp sites. For example, distance between sites had no discernible effect on the similarity of species composition between sites. Adjacent sites had both the highest (0.74, I and II) and one of the lowest (0.42, I and III) index of similarity values (Table 4).
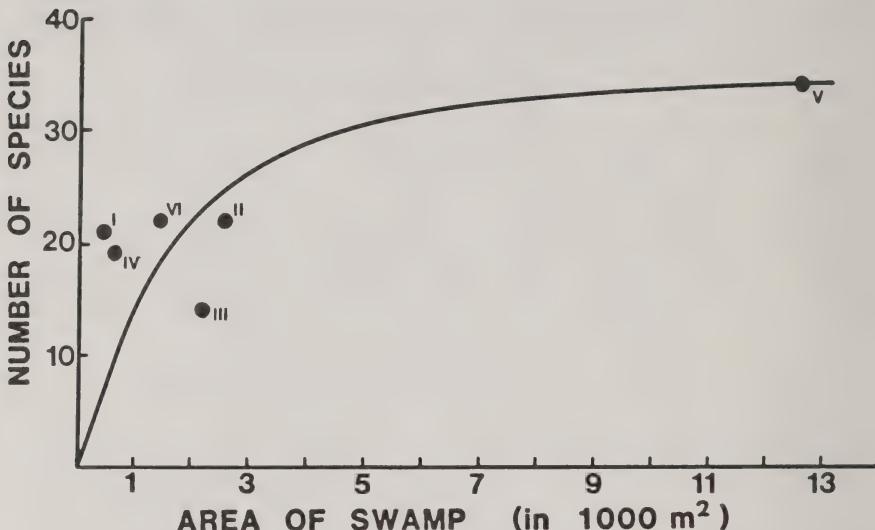
Fig. 3. Number of species found in the six buttonbush swamp sites surveyed in Gahanna Woods State Nature Preserve, plotted as a function of swamp size (area). An "expected" species-area curve is fitted by eye over the data points. Site numbers (I–VI) are indicated.

All the site factors mentioned above may play an integrated role in determining species composition of the sites. Two other factors which may be involved as well, but which were not assessed in this study, are the extent of canopy cover by adjacent swamp forest trees, and the successional status of the sites.

Although the index of similarity values for buttonbush sites varied greatly (0.39–0.74), this wide range of values need not be considered as evidence against the concept of the buttonbush community. Curtis (1959), after obtaining an index of similarity of 0.64 for within county stands (= sites) and 0.54 for between county stands of mesic forest in Wisconsin, concluded that there is great stand-to-stand variability for any given community. Andreas & Osterbrock (1985), likewise, found variability among three "stands" of the bog community in Ohio.

Some of this variability among sites may be related to the wide range of environmental tolerances (i.e., ecological amplitude) of *Cephalanthus*. *Cephalanthus* is widespread geographically and grows throughout the eastern U.S. and across the lower tier of western states (Brockman 1968). It has been found growing in swamps, sloughs, shallow ponds, small streams, stream banks, and marshes (Godfrey & Wooten 1981). Beal (1977) reported the species to have a broad pH tolerance and other habitat requirements. Deane (1902) reported buttonbush persisting in a "henyard" where a swampy area was filled in with three feet of soil. The tolerances of *Cephalanthus* appear to exceed those of other wetland species. Thus, a wetland flora in a site of certain soil and moisture conditions may show little similarity to that of another locale, although *Cephalanthus* may grow in both areas due to its much wider range of tolerances.

The index of homogeneity for the buttonbush swamp sites at Gahanna Woods (0.75) was higher than any value Curtis (1959) obtained in stand-to-stand comparisons for plant communities in Wisconsin. His values ranged from 0.34 for the beach community to 0.70 for the dry prairie. Thus, despite physical, floristic, and vegetational differences, the concept of the buttonbush swamp as a distinct community is supported by this study on the basis of the large index of homogeneity.

The four other species that were present in all six buttonbush sites surveyed (*Boehmeria cylindrica, Scutellaria lateriflora, Sium suave*, and *Bidens comosus*) are common in many wetland areas. These plants are probably growing in association with *Cephalanthus* only in the sense that they share the wetland habitat. There is no evidence that any other species found in this survey is restricted to buttonbush swamps (i.e., an indicator species for buttonbush swamps). However, certain plant families such as the Polygonaceae and Cyperaceae are typically well represented in buttonbush swamps, although which species are present may differ from site to site. Thus, the buttonbush community in central Ohio is comprised of *Cephalanthus occidentalis* and, because of this species' wide range of tolerances, a somewhat variable assemblage of other wetland plants.

SUMMARY

During October and November 1984, a floristic survey was conducted in six buttonbush swamps in Gahanna Woods, a 20.2 ha state nature preserve in eastern Franklin County, Ohio. Fifty-six species of flowering plants were identified within the sites surveyed, adding 20 species to the flora of Gahanna Woods compiled in the spring and summer of 1976. The most notable addition to this flora was *Carex decomposita* Muhl., which had not been collected in Ohio since 1910, and which previously had been considered extirpated from the state. The greatest number of species was found at the largest swamp site. There was considerable variability in species composition among sites; the index of similarity for between-site comparisons ranged from 0.39 to 0.74. Differences in water level regimes, soil type, distance between sites, and site area probably all contribute to the differences in species composition among sites, as no one factor common to any two sites corresponded consistently with high indices of similarity. The index of homogeneity for the sites was high (0.75), offering support for the recognition of the buttonbush shrub swamp as a distinct plant community in central Ohio. Aside from *Cephalanthus*, however, no other species was a good indicator of this community type, although several widespread wetland plants occurred at all sites.

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On the cover: *Warren Woods Forest Primeval Preserve. Photo by Gerrard T. Donnelly,*
August 29, 1986.

THE

MICHIGAN BOTANIST

March, 1987

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POST-SETTLEMENT CHANGES IN TREE COMPOSITION OF SOUTHEASTERN WISCONSIN FORESTED WETLANDS

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Ranking site characteristics and disturbance in order of importance as determinants of vegetation structure and composition is difficult, particularly because site characteristics can be measured directly, but disturbance history must often be inferred (Lorimer 1985). In reality, there is likely to be an interaction between disturbance and site (Dunn 1985). The recent vegetation history of southeastern Wisconsin forested wetlands presents such a problem. The original land survey records (ca. 1836), when compared with present tree composition (Dunn 1985), indicate that significant changes have taken place. Although site characteristics, particularly soils, appear to be related in some measure to species composition, other factors are also important. Historical disturbances that may have helped shape the character of these forested wetlands include post-settlement logging (Luebke 1976), larch sawfly infestation (Curtis 1959), and Dutch elm disease (Dunn 1986). Forested wetlands are common in much of the Great Lakes area, including Wisconsin (Ware 1955, Dunn 1985), Michigan (Barnes 1976), and Ohio (Sampson 1930, Collins et al. 1979).

The purpose of this paper is to describe changes in tree species abundance and composition since settlement in 15 forested wetland stands in southeastern Wisconsin and to suggest several hypotheses which may account for these changes (e.g., successional processes, natural disturbance, human disturbance, or some combination of these).

STUDY AREA

This study was conducted in six southeastern Wisconsin counties (Fig. 1). Major settlement of the area took place after 1830 (Curtis 1959). The government land survey was completed between 1835 and 1836.

Two kinds of forested wetland, floodplain and lacustrine, are present. Lacustrine (depressional) stands are more common, mainly because most floodplains have been cleared for agriculture.

Lacustrine soils are Histosols, with depth of organic muck ranging from 80–110 cm. Floodplain soils are predominately Mollisols (especially silt-loam) and poorly-developed wet mineral soils (Fluvaquents and wet alluvial land). Water remains at or near the surface most of the year in both kinds of stands.

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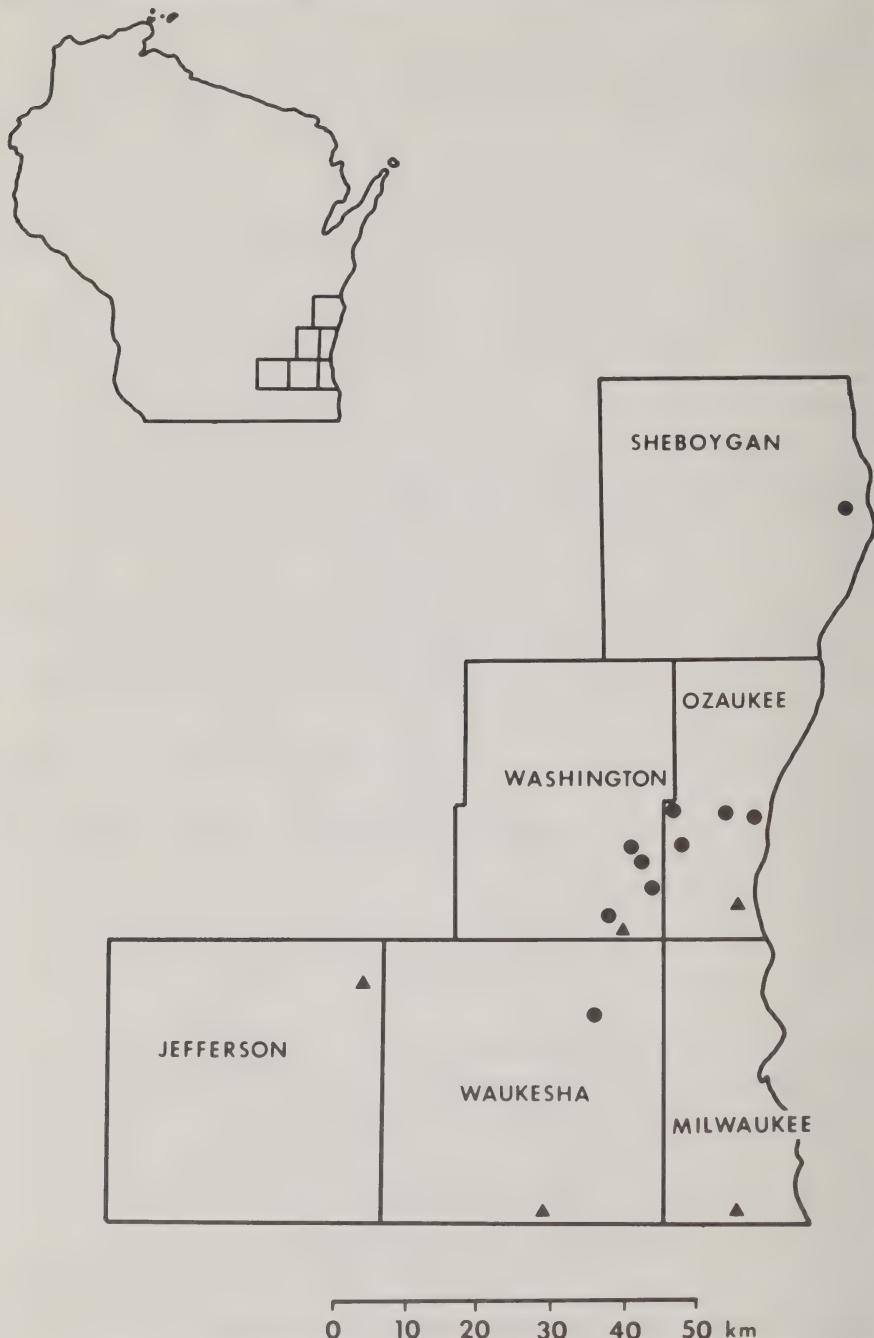
Fig. 1. Location of 15 forested wetlands in southeastern Wisconsin, used to compare presettlement with present-day tree canopy composition. ▲ = floodplain stands, ● = lacustrine stands.

<div align="center">METHODS</div>

Presettlement Vegetation

Some idea of the tree species present in forested wetlands around 1836 can be gained from the original land survey records. Both exterior lines (township boundaries) and interior lines (section boundaries) were surveyed. Each township is 6 sections (miles) on a side, for a total of 36 sections. At each section corner, 2–4 trees were recorded by the surveyors, and species, diameter, and distance from that corner were noted. The surveyors made similar notes halfway along each section line (80 chains = 1 mile, or 1.6 km). As the surveyors walked along the line, they also identified and measured any tree that intersected their line. Notes such as "entered swamp," "leave swamp," or "leave same" were also made and helped in deciding which trees to use in this analysis.

After determining the township, range, and section(s) for each study site, I copied the surveyors' notes on tree species density and diameter for those portions of section lines entering swamps, marshes, or crossing rivers. Portions of fifty-seven section lines (miles) were detailed in this manner. Tree diameters, given in inches, were converted to metric units and then to basal area. (m^2).

Present Vegetation

Five floodplain and ten lacustrine stands were chosen for study. Vegetation was sampled systematically using a metric modification of Lindsey's (1955) line-strip method. Transects 100 m × 10 m were subdivided into four 25 m × 10 m plots. All trees (woody stems ≥ 10 cm diameter) were recorded by species and diameter. Stem diameters were converted to basal area per hectare (m^2/ha). Number and size of dead canopy trees were recorded. Most dead trees could be identified to species based on remnant bark and wood characteristics. Shrub species (woody stems < 2.5 cm basal diameter) were sampled in 10 m × 2.5 m nested plots and data were recorded in terms of density and percentage cover. The number of transects per stand ranged from 4 to 8, depending on stand area. Species nomenclature follows Little (1979).

Data Analysis

Presettlement and present tree composition were compared using the Mann-Whitney test (Zar 1974). Species composition was defined as relative density. Linear regression was used to test the significance of association between the density of dead canopy trees (i.e., disturbance) and density of shrubs.

<div align="center">RESULTS</div>

Presettlement Vegetation

Presettlement forests were dominated by black ash with, in some areas, a sizeable number of tamarack (Table 1). Six other species, including American elm, were relatively rare. White cedar had only one third the density of tamarack but had the same basal area. Evidently, the presettlement white cedar were fairly large trees.

A notable feature of the presettlement vegetation, as recorded by the land surveyors, was the absence of silver maple, red maple (*A. rubrum*), and green ash along the 57 section lines. I subsequently reviewed all the surveyors' notes for the 10 townships (360 mi² total) in which my study sites occurred and noted only 30 references to "maple" and "red maple."

Because sugar maple (*Acer saccharum*) was called "sugar," it is probable that "maple" meant either red or silver maple. Most references to maple

TABLE 1. Density (D; no. trees), basal area (BA; m^2), relative density (RD), and relative basal area (RBA) of trees recorded in 1846 in lowland areas along 57 section lines in southeastern Wisconsin.

SPECIES	D	BA	RD	RBA
Fraxinus nigra	51	4.62	54.2	56.4
Larix laricina	21	1.22	22.3	14.9
Thuja occidentalis	7	1.19	7.4	14.5
Ulmus americana	9	0.87	9.6	10.6
Populus deltoides	2	0.06	2.1	0.7
Quercus alba	1	0.09	1.1	1.1
Acer saccharinum/rubrum	1	0.07	1.1	0.8
Betula alleghaniensis	1	0.05	1.1	0.6
Salix sp.	1	0.02	1.1	0.2
TOTAL	94	8.19	100	100

occurred along rivers in the southern part of the study area. I separated the maple records into lacustrine and floodplain ones based on the surveyors' description. That is, if the land surveyor noted the presence of maples in ''swamps,'' the record was considered to be lacustrine. Maples noted along river banks were considered to be floodplain trees. The mean presettlement lacustrine site contained reference to 1.6 ''maples.'' This number is significantly lower [t = 2.896, t (critical) = 1.860, DF = 9] than in floodplain sites ($\bar{x}$ = 5.0). This substantiates the statement by Ware (1955) that silver maple in Wisconsin at the time of settlement was primarily confined to river courses.

Present Vegetation

The tree stratum of southeastern Wisconsin forested wetlands is now largely dominated by silver maple, American elm, green ash, and black ash (Table 2). Twenty-four tree species were encountered in the 15 stands I examined. The number of tree species per stand ranged from 4 to 10, and the average stand contained 7 species. Only silver maple and American elm occurred in all stands. The importance value of silver maple ranged from < 1% to over 76%, while American elm ranged from 1.2% to almost 23%. Yellow birch (*Betula alleghaniensis*) was locally abundant. Total stand density ranged from 270 trees/ha to 683 trees/ha and basal area from 14 m^2/ha to 41 m^2/ha.

In his study of southern Wisconsin forested wetlands, Ware (1955) also noted the dominance by silver maple and American elm. He used data from Cheney (1893) to demonstrate that silver maple (and other species uncommon in my stands) was almost entirely confined to major stream courses. This contrasts sharply with my finding that the rank of average relative density of silver maple in floodplain stands today is no different [Mann-Whitney U = 33, U (critical) = 42, P > 0.2] than in lacustrine ones.

Some tamarack and white cedar are present, but many trees are dead or appear to be dying. Although I selected sites that were predominantly hardwood, the presettlement data indicate that these two conifer species were more common

TABLE 2. Summary of the present tree stratum of 15 forested wetlands in southeastern Wisconsin.

SPECIES	D (No./ha)	BA (m²/ha)	RD	RBA
Acer saccharinum	164	13.5	39.1	52.4
Fraxinus nigra	61	1.7	14.6	6.6
Fraxinus pennsylvanica	56	3.4	13.4	13.2
Betula alleghaniensis	39	1.3	9.1	5.0
Acer rubrum	22	1.7	5.2	6.6
Ulmus americana	19	0.7	4.5	2.7
Acer negundo	16	0.4	3.8	1.6
Crataegus sp.	14	0.3	3.3	1.2
Salix nigra	8	1.2	1.9	4.7
Quercus bicolor	8	0.7	1.9	2.7
Tilia americana	5	0.2	1.2	0.8
Celtis occidentalis	1	0.06	0.2	0.2
Larix laricina	1	0.05	0.2	0.2
Carya ovata	1	0.03	0.2	0.1
Betula papyrifera	1	0.01	0.2	0.04
Acer saccharum	0.7	0.01	0.2	0.04
Quercus macrocarpa	0.6	0.2	0.1	0.8
Juglans nigra	0.4	0.04	0.1	0.2
Fraxinus americana	0.3	0.02	0.1	0.1
Rhamnus cathartica	0.3	0.02	0.1	0.1
Populus deltoides	0.2	0.2	0.05	0.8
Thuja occidentalis	0.2	0.01	0.05	0.04
Carya cordiformis	0.2	0.002	0.05	0.01
Ulmus rubra	0.2	0.002	0.05	0.01
TOTAL	419.1	25.754	100	100

in the hardwood mixture in the past (Table 1) than they are today (Table 2). For one reason or another, a major shift in species composition appears to be taking place. The evidence for the shift is three-fold. First, few silver and red maple were noted in the original land survey. Second, the surveyors' notes for the study sites suggest a black ash-tamarack-American elm complex. Although ash and elm are still common, tamarack is now rare. Third, American elm is still present, but not in large numbers. Most elm trees are small and probably became established recently from seed of the few remaining seed trees.

Elm Mortality

Mortality of American elm resulting from Dutch elm disease has been severe in several stands (Dunn 1986). In general, environmental conditions in large canopy gaps (esp. increased light levels) favor shrubby growth normally associated with open habitats (Dunn et al 1983, Huenneke 1983, Dunn 1986). A linear regression of dead elm density on shrub density, suggests that as dead elm density increases, so does shrub density (Fig. 2). Consequently, lowland forests suffering moderate to severe elm mortality (> 5 dead elm per hectare) may become more shrubby. Such shrub communities may persist, inhibiting tree
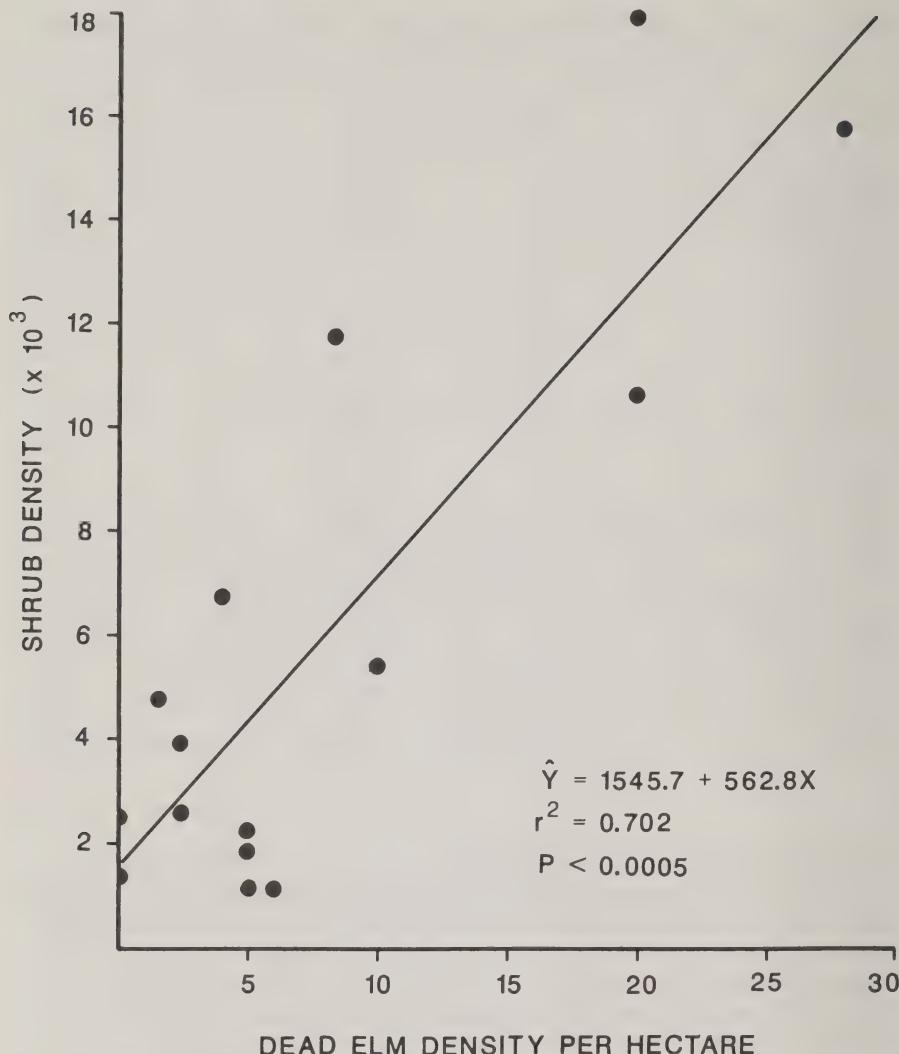
Fig. 2. Linear regression of number of dead trees per hectare vs. shrub density per hectare for 15 forested wetlands in southeastern Wisconsin.

regeneration (Huenneke 1983). In stands with low elm mortality ($<$ 5 dead elm/ha), elm may largely be replaced by other tree species with elm persisting as short-lived individuals capable of re-seeding (Barnes 1976, Parker & Leopold 1983).

DISCUSSION

Lowland forests of southeastern Wisconsin today are different from the lowland forests at the time of European settlement. Forests once dominated by

black ash, tamarack, and white cedar are now dominated by silver maple, black ash, and green ash. Several hypotheses can be advanced to explain these changes in tree composition. The first involves successional processes, perhaps influenced by climatic change in recent post-Wisconsinan time. Hardwood species, such as silver maple, that may have been subdominant in a tamarack or white cedar community, gradually gained dominance over the coniferous species as the regional climate changed (Sampson 1930, Ware 1955, Christensen et al 1959, Barnes 1976, Davis 1979). On the other hand, Collins et al (1979) examined succession in an Ohio white cedar swamp and noted the stability of white cedar as the dominant. They suggested that red maple and black ash may increase in importance, but will probably reach only subdominant status.

A second hypothesis is that postsettlement logging of tamarack (Vogl 1969, Luebke 1976, Davis 1979) opened the canopy of many forested wetlands. The increased resource levels (of light, nutrients from logging residue, space, etc) and soil disturbance may have provided silver and red maple suitable sites for germination and growth. A similar explanation was proposed for northern Michigan by Gates (1942) who noted that black ash and red maple dominated following logging of bogs. In contrast to southeastern Wisconsin, however, neither silver maple nor American elm were common in logged forested wetlands of northern Michigan (Gates 1942). Another opportunity for maple increase may have been recent canopy removal resulting from larch sawfly (1900–1910; Curtis 1959) and Dutch elm disease (1950s). In addition, roads were built through wetlands ("plank roads"), thereby impeding surface and subsurface flow of water (Ware 1955). Road and dam building may well have reduced survival of certain species, particularly tamarack (Luebke 1976).

A third hypothesis to explain vegetation change incorporates elements of the previous two. Silver maple may have moved gradually into southeastern Wisconsin along rivers from the south and west. This migration route is supported by Durkee (1971) who noted the presence of silver maple in the presettlement flora of two sites in north-central Iowa. He suggested that deciduous species followed rivers and streams from the southeast into Iowa. Ware (1955) also suggested a northward migration of certain tree species (e.g., red maple) along river courses; however, he did not mention a possible migration route for silver maple. Because the presettlement lacustrine stands in southeastern Wisconsin were dominated by conifers, a shade-intolerant species such as silver maple may have had difficulty becoming established. As the canopy of the lacustrine stands was opened, seedlings originating from floodplain trees may have become established. Silver maple was present decades ago in some Ohio swamps (Sampson 1930). Floodplain forests along the Wabash River in Indiana also contain a considerable amount of silver maple (Lindsey et al 1961, Philippe & Ebinger 1973). Clearly, silver maple is not new to the Midwest and may have gradually invaded and succeeded in lacustrine stands even without canopy opening.

To determine the most likely reason for shifts in species composition and abundance would require a long-term study. The three hypotheses discussed here cannot be tested rigorously given the nature of this study, but do suggest possible mechanisms that should be topics of future research.

SUMMARY

The dominant tree species of southeastern Wisconsin lowland forests have changed considerably since the government land survey of 1835–1836. Forests that were once dominated by black ash, tamarack, white cedar, and American elm are now typified by silver maple, black ash, and green ash. The most likely causes of this change include (1) loss of tamarack to logging and larch sawfly, (2) loss of white cedar to logging, (3) loss of American elm to Dutch elm disease, and (4) post-Wisconsinan climatic change. These mechanisms, probably acting together, created conditions favorable for the rapid colonization by silver maple and green ash. Those stands that suffered particularly severe elm loss have become shrubby, a condition that may remain and inhibit tree regeneration. A combination of human and natural processes appears to be responsible for the present character of the tree layer of these forests.

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REVIEW

A DESCRIPTIVE KEY TO THE GRASSES OF OHIO BASED ON VEGETATIVE CHARAC-TERS. By Clara G. Weishaupt. 1985. Bull. Ohio Biological Survey Vol. 7, No. 1. 99 pp. Ohio Biological Survey, 484 W. 12th Ave. Columbus, Ohio 43210. $12.00 + 20% postage and handling.

This book is certainly not bedtime reading. It is densely packed with a great deal of information. Most of the text is, as the title indicates, a detailed vegetative key to Ohio grasses. Whenever a species is keyed down, there is, following the name, a common name, a brief paragraph giving the status of the species in Ohio, the number of Counties it is recorded from, the habitat, and a brief description of the plant. I did not test the keys, but reading couplets concerning species I knew well suggests that the keys should be accurate and as workable as any vegetative key. Of course, the book will also be a useful supplement to regular keys. Although only 11 references are listed, taxonomy and nomenclature reflect modern treatments for the most part.

Anyone who regularly needs to identify grasses in the Great Lakes region should own this book. It should also be of value to botanists working on grass systematics.

A. A. Reznicek

LENTIBULARIACEAE: THE BLADDERWORT FAMILY IN WISCONSIN

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This treatment of the Lentibulariaceae in Wisconsin is an update of Thomson's Preliminary Report on the Flora of Wisconsin (1940). In the interval following Thomson's publication, extensive collecting has expanded the known distribution of the eight native species of Bladderwort (*Utricularia*) in the state. An additional genus in the family, Butterwort (*Pinguicula*) also was discovered.

Specimens in the following herbaria were examined: Beloit College, Beloit, WI; Field Herbarium, Chicago, IL; Milwaukee Public Museum, Milwaukee, WI; Morton Arboretum, Lisle, IL; Northland College, Ashland, WI; University of Wisconsin system herbaria in Eau Claire, Green Bay, LaCrosse, Madison, Milwaukee, Oshkosh, River Falls, Rock County-Janesville, Stevens Point, and Superior; and the private collections of Mrs. Katherine Rill and the author. Each specimen was annotated and, if its location was mapped, stamped ''Mapped For Flora of Wisconsin'' and dated. In addition to recording these data, the author observed and collected all of the species throughout the state.

Each dot on the range maps indicates the locality at which an herbarium specimen was collected. Due to space limitations only one location for each township was mapped. A hollow symbol indicates a county record only. No sight records were mapped. Phenological data gathered from specimens is presented at the lower left corner of each map and indicates the time and duration of flowering and fruiting.

The brief description of each species is after Fernald (1950). Outstanding illustrations of several of Wisconsin's Lentibulariaceae can be found in Correll and Correll (1972) (*Utricularia cornuta, U. purpurea, U. vulgaris,* and *U. gibba*) and in Godfrey & Wooten (1981) (*U. resupinata*). Schnell's book (1976) contains photographs of several of our species in the Bladderwort family.

LENTIBULARIACEAE

Small, annual or perennial, aquatic or terrestrial, herbaceous, carnivorous plants which trap small aquatic animals in bladder-traps (*Utricularia*) or aerial insects on viscid leaf surfaces (*Pinguicula*). Branches alternate or whorled, divided into one to many filiform segments, some bearing bladder-traps (*Utricularia*), or basal, elliptic to ovate with involute margins, soft and fleshy (*Pinguicula*). FLOWERS perfect, irregular, solitary or in a short raceme, usually bracteate. CALYX 2- or 5-lobed. COROLLA sympetalous, 2-lipped, spurred. STAMENS 2, borne on the base of the corolla. OVARY superior, 1-locular, with free central placentation. STYLE very short. STIGMA 2-lobed. FRUIT a

Fig. 1. Range maps of Wisconsin species of *Utricularia:* 1) *U. resupinata* Green; 2) *U. purpurea* Walt; 3) *U. intermedia* Hayne; 4) *U. minor* L.; 5) *U. gibba* L.; 6) *U. cornuta* Michx.; 7) *U. vulgaris* L.; 8) *U. geminiscapa* Benj.

capsule, seeds numerous. Four (5) genera of worldwide distribution, the number of species uncertain, but more than 400 species have been described.

The genera in the Bladderwort family are: 1) *Biovularia*, which Taylor (1967) considers should be united with *Utricularia*; 2) *Genlisea*, which occurs in South America, tropical and South Africa, and Madagascar, and has tubular traps. Thirty-two species have been described, but Taylor (1967) feels the actual number is less than half that; 3) *Pinguicula*, including about 35 species, two of which are circumboreal, numerous species European, especially in the Mediterranean region, the remainder American in the southeastern United States, Mexico, Cuba and south in the Andes to Colombia and Venezuela; 4) *Polypompholyx*, an Australian genus, some members of which are closely

related to *Utricularia*; and 5) *Utricularia*, with more than 300 species described but perhaps only 170 species according to Taylor (1975). The genus is widely distributed in tropical areas with relatively few species in temperate regions. The chief concentrations of species are in eastern tropical South America and the West Indies, southcentral tropical Africa, southeast Asia, and tropical Australia.

KEY TO THE GENERA OF THE LENTIBULARIACEAE IN WISCONSIN

Branches divided into filiform lobes, alternate or whorled; plants terrestrial or aquatic; calyx 2-lobed; bladder-traps usually present ..
....I. *Utricularia*

Leaves entire, basal, sticky and carnivorous; plants terrestrial; calyx 5-lobed; bladder-traps absent...............................II. *Pinguicula*

I. Utricularia, Bladderwort

There are eight species of Bladderwort native to the state in quiet waters of lakes, streams, ponds, and wetlands except in the well dissected topography of the "Driftless Area" where there are few such areas. One species, *Utricularia vulgaris*, is nearly ubiquitous in wetlands and waters throughout the state, while *U. cornuta* and *U. intermedia* are very common but do not range as widely in the state. The other five species are much less frequently encountered in the field.

Bladderworts have elaborate bladder-traps, activated by trigger hairs. When the trap is tripped, aquatic creatures are drawn into the bladder-trap and the door shuts behind them. The trap fires within 10–15 milliseconds after mechanical stimulation (Sydenham & Findley 1973). Following capture, the plants secrete enzymes which break down the proteins of its prey, which the plant subsequently absorbs and utilizes.

In describing the Bladderworts, it is convenient to distinguish between stems, branches, leaves, and in some, rootlets. In this group, however, there is morphological evidence that points to a vegetative system comprised only of a stem, parts of which may appear leaf-like or root-like.

The Bladderworts confined to temperate regions (e.g., *Utricularia minor*, *U. vulgaris*, and *U. intermedia*) produce free floating winter buds (turions), and in this form the plant overwinters beneath the ice. Winter buds consist of small, very tightly crowded leaf-like branches which rapidly elongate in the spring to form mature plants. Winter buds vary between species, and diagnostic characters have been included in the key. *Utricularia cornuta* and *U. resupinata* apparently do not produce winter buds, while those of *U. purpurea* and *U. geminiscapa* are loosely formed and unspecialized.

In the field, collectors should be alert for sterile Bladderworts, for the majority in an area do not flower and thus are inconspicuous. Many collectors overlook them or choose not to collect sterile specimens. Moreover, some plants

may be hidden by silt deposits or algae, and it is often productive to probe bog pools or sandy lake bottoms by hand and carefully examine what comes to the surface. The presence of tiny bladders is definitive! Collectors then should take the time to float out the limp aquatic Bladderworts onto herbarium sheets to facilitate correct determinations. This also reduces the likelihood of mixing specimens on an herbarium sheet.

Sterile Bladderwort collections, even of the more delicate species, can be identified to species assuming care has been taken during collection to separate the plant from its substrate so that a complete specimen is obtained. A good dissecting scope is very useful in keying sterile material. The following keys are based on flowering and sterile material.

KEY TO THE WISCONSIN SPECIES OF UTRICULARIA

Key to Flowering Material

A.   Flowers petaliferous and conspicuous (chasmogamous), on erect scapes or racemes.

    B.   Flowers purple.

        C.   Flowers solitary and terminal, resupinate (upside down); bract connate; plants aquatic or terrestrial, firmly anchored in peat, sand or mud, with horizontal, subterranean stems bearing erect, subulate branches with a few scattered bladder-traps . . . . .1. *U. resupinata*

        CC. Flowers 2–5 on axillary scapes, not resupinate; bracts none; plants aquatic, free floating, with whorled many-divided stems bearing many bladder-traps at their tips . . .

           . . . . 2. *U. purpurea*

    BB. Flowers yellow.

        D.   Lower lip of the corolla about twice the length of the upper; stem segments flat, the midrib obvious.

           E.   Corolla spur 8–12 mm long, nearly as long as the lower lip; flowers bright yellow; traps only on subterranean nearly leafless branches; stems dimorphic, on exposed branches 1–2 mm wide, 5–30 mm long, green, on buried branches reduced, nearly colorless; pedicels erect in fruit; scape with 2–5 flowers . . . . .3. *U. intermedia*

           EE. Corolla spur reduced-saccate, less than 2 mm long and much shorter than the lower lip; flowers pale yellow; bladder-traps on most leafy branches; stems 1–3 mm wide, to 10 mm long; pedicels recurved in fruit; scape with 3–15 flowers . . . . .4. *U. minor*

        DD. Lower lip of the corolla about the same as the upper; stem segments capillary, without a midrib.

  F. Flowering plants terrestrial on quaking bogs, bare peat, marl, mud, or sand; stems and branches buried and enmeshed in the substrate.

    G. Calyx lobes green, equal, about 2 mm long; spur inconspicuous, less than 5 mm long and parallel to the lower lip; bract clasping, without an inner pair of bracts; scape to 6 mm tall bearing 1–2 flowers.....................5. *U. gibba*

    GG. Calyx lobes yellow, unequal, the longer 4–5 mm long; spur conspicuous, longer than 5 mm and nearly perpendicular to the lower lip; bract not clasping, with an inner pair of bracts; scapes 10–35 cm tall bearing 2–7 flowers. ...

     .... 6. *U. cornuta*

  FF. Flowering plants aquatic; stems free floating, often lying near the bottom in shallow water or on detritus.

    H. Plants slender to robust, branches to 10 cm wide; branch segments denticulate-bristly with elongate spines (under magnification); basal branch divisions 0.5–1 mm in diameter; scape with 1–5 cordate-sessile scales; pedicels recurved in fruit. ....7. *U. vulgaris*

    HH. Plants always slender and delicate, branches rarely over 3 cm wide; basal branch divisions about 0.25 mm in diameter; leaf segments spineless except at the tips; scapes without scales; pedicels erect in fruit. ....8. *U. geminiscapa*

AA. Flowers without petals, inconspicuous (cleistogamous), submerged, short-stalked in few axils. ....8. *U. geminiscapa*

Key to Sterile Material

A. Leaf-like branches simple; plants with buried horizontal stems bearing erect leaf-like branches.

  B. Plants with bladder-traps.

    C. Intact specimens with 2 white rootlets from the base of the erect branches................................1. *U. resupinata*

    CC. Intact specimens with (0) 3–4 white or brown rootlets from the base of the erect branches..............6. *U. cornuta*

  BB. Plants without bladder-traps. .... 6. *U. cornuta*[1]

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[1]Submersed, sterile specimens of *Utricularia cornuta*, sometimes collected without traps, often occur with the superficially similar *Myriophyllum tenellum*. *U. cornuta* has more slender leaf-like structures, which are circinate when young, and *M. tenellum* has rootlets arising at the base of the erect stems as well as between the stems along the stolon; those of *U. cornuta* arise only from the base of the erect leaf-like branches. *M. tenellum* possesses leaves which appear as alternate bumps

AA. Leaf-like branches divided; plants with stems resting on or above the
bottom substrate.
D.   Branches whorled. ....2. *U. purpurea*
DD. Branches alternate.
    E.   Leaf-like branch segments flattened; midrib evident.
        F.   Traps borne on subterranean nearly undivided
branches; segments 5–30 mm long; winter buds
gray-green, 5–10 mm long, their small stem divi-
sions bordered with dense tufts of coarse hairs. ....
.... 3. *U. intermedia*
        FF. Traps borne on most leaf-like branches; leaf-like
segments to 10 mm long, their stem divisions with
few hairs....................................4. *U. minor*
    EE Leaf-like branch segments capillary, without a midrib.
        G.   Branches usually once divided from near the base,
rarely with up to 3 divisions, 2–8 mm long. .5. *U. gibba*
        GG. Branches with several to many divisions, mostly
more than 8 mm long.
            H.   Plants robust; leaf-like segments denticulate–
bristly with elongate spines; basal branch divi-
sions 0.5–1 mm in diameter; winter buds
1–2 cm in diameter. .... 7. *U. vulgaris*
            HH. Plants delicate; leaf-like segments spineless
except at tips; basal branch divisions about
0.25 mm in diameter; winter buds 2–5 mm in
diameter.........................8. *U. geminiscapa*

1. *Utricularia resupinata* Greene   Small Purple Bladderwort   Map 1
   Lecticula resupinata (Greene) Barnh.

    Terrestrial or aquatic, forming thin mats with filiform, subterranean stems and erect, delicate,
linear leaf-like branches bearing tiny traps; filiform scapes 5–30 cm tall bearing a single flower and
subtended by a single cone-shaped bract; corolla purple, 6–12 mm long, transversely oblique, the
broad and round lower lip much longer than the narrowly obovate upper one; spur shorter than the
lower lip.
    Rare in northern and central Wisconsin, occurring on sandy lake shores, often emersed and in
water to 15 cm deep, in deeper water, especially in clear water lakes in Vilas County, persisting in
sterile clones much like *Utricularia cornuta*. The stolons and erect leaf-like branches of *U.
resupinata* usually are thoroughly enmeshed in the wet substrate, and form a tiny green turf. In most
collections the flower scape is pulled free from the remainder of the plant.
    At its most southerly location in Marquette County, it is present in Tuttle Lake, a sand bottom
seepage lake in ground moraine with fairly clear, medium hard water. In Vilas County in the north,
it has been collected from Camp, Clear, Little John Jr., Oberlin, and Vandercook Lakes, all slightly
acid seepage lakes with clear, soft waters and sand bottoms.
    Range: From Ontario (Thunder Bay), southern Quebec and Nova Scotia, south to Delaware,
inland south to Pennsylvania, northern Indiana, and northern Illinois, and on the coastal plain in
Georgia, Alabama and throughout Florida; South America (British Honduras, Venezuela, Brazil).

on the stem accompanied by a dark line encircling the stem. For an excellent key to the sterile,
submerged aquatics, refer to Voss (1972).

2. *Utricularia purpurea* Walt.   Purple Bladderwort   Map 2
   Vesiculina purpurea (Walt.) Raf.
   Vesiculina saccata Raf.

Branches whorled along the free floating stem, long-petioled, decompound, with traps borne at the tips of some leaf-like segments; peduncles 2–5 flowered; corolla deep pink to purple 1–1.3 cm broad, the somewhat flattened spur appressed to the 3-lobed, 2-saccate lower lip and about half its length.

Utricularia purpurea is a robust aquatic Bladderwort readily distinguished by its whorled branches and terminal traps. It is rare in northern and central Wisconsin, occurring in boggy and other soft water lakes. Where found, it often occurs in large numbers. It probably is more common than collection records indicate because often it is sterile, and thus inconspicuous, and few botanists venture into the many small bog lakes where it occurs. At its southernmost locations in Pickerel and Silver Lakes, Waushara and Marquette Counties, respectively, thousands of Purple Bladderwort flowers can be seen in August and September where it occurs in the shallow portions of the lakes.

Range: In the Great Lakes region from Minnesota, Michigan, and northern Indiana, eastward across southern Quebec and Ontario to Newfoundland, New Brunswick and Nova Scotia, south through New England to New York and on the coastal plain chiefly from Virginia to Florida and west to eastern Texas; West Indies; Central America.

3. *Utricularia intermedia* Hayne   Flat-leaved Bladderwort   Map 3

Creeping, submerged in shallow pools or on wet substrates, the pale traps borne on subterranean branches separate from the distichous, trapless leaf-like branches; the latter 0.5–1.5 cm across, their segments flat; racemes or panicles of traps up to 15 cm long; scapes 5–30 cm tall, 2–5 flowered; corolla 1.2–2 cm high, the broadly deltoid upper lip much shorter than the broad-ovate lower one, the spur appressed to the lower lip and nearly as long; winter buds ovoid, dense, hairy, 3–10 mm long.

Utricularia intermedia, our second most frequent Bladderwort, is found primarily in the glaciated regions of the state and in the former Glacial Lake Wisconsin in the central portion of the state. It occurs in quiet waters in *Sphagnum* bogs and bog pools, lake and stream edges, sedge meadows, calcareous fens and Great Lakes beach pools and swales. Small depressions between tussock sedges or along animal trails through bogs or fens provide habitats for this Bladderwort. In the field its green leaf-like branches are conspicuous in shallow waters, while its colorless branch bearing bladder-traps lies hidden beneath the substrate. In overall appearance, Flat-leaved Bladderwort is most similar to *U. minor*, although usually somewhat larger.

Range: Northern Alaska eastward across the continent to northern Quebec and Labrador, south to Delaware, Pennsylvania, Ohio, northern Indiana, northern Illinois, northern Iowa, and in the Pacific Northwest in Washington and California; western central Greenland and Iceland; most of Europe southward to France, northern Italy and southcentral Russia; eastern Asia. The circumpolar range of the species was mapped by Hulten (1971), map 98.

4. *Utricularia minor* L.   Lesser Bladderwort   Map 4

The creeping, usually submersed stems thread-like, with 2–4 times forked leaf-like branches with flat, entire segments, 2–12 mm across, many of them with traps; scapes filiform, 3–20 cm high, 2–9 flowered; corolla pale yellow, 5–8 mm long, the upper lip not extending beyond the depressed and obscure palate, lower lip prolonged, spur very short and saccate or almost wanting; pedicels recurved in fruit.

Utricularia minor is of infrequent occurrence in the eastern and northern portions of the state in the glaciated areas. It has been collected from quiet, shallow waters of sedge or tamarack bogs, bog pools, Great Lakes beach pools and swales, calcareous sedge meadows with standing water, and marshy lake edges. In southeastern Wisconsin, it is found in calcareous fens, cold spring seeps, and stream edges.

Lesser Bladderwort is sometimes confused with *Utricularia intermedia*, with which it often occurs, for both have flat leaf-like segments. The bladder-traps of *U. minor* are borne on branches with almost colorless, somewhat reduced segments, while those few branches without bladders are

greener and more robust. In contrast, the bladder-traps of *U. intermedia* are borne on colorless branches buried in the substrate. In addition, the small and pale yellow flowers of *U. minor* are inconspicuous compared to the larger, brighter yellow flowers of *U. intermedia*.

Range: Alaska eastward across the continent to Labrador, south to New Jersey, Pennsylvania, Ohio, Indiana, Iowa, Colorado, Utah, and California; western Greenland; Iceland and most of Europe; central and eastern Asia. The world range of this circumpolar species was mapped by Hulten (1971), map 99.

5. *Utricularia gibba* L.   Swollen-spurred or Humped Bladderwort   Map 5

Delicate, with filiform creeping or floating branches; the sparse leaf-like plumes of foliage 0.5–2 cm in diameter and up to 30 cm long, often intricately entangled in the substrate; scapes 2–9 cm high, 1–3 flowered; corolla yellow, 6–12 mm high, 6–8 mm broad, the nearly equal lips projected forward, the conic spur much shorter than the lower lip.

Utricularia gibba is infrequent in the state in quiet shallow waters on muddy bog flats, muddy or sandy shores, and calcareous sedge mats. Flowering specimens I have seen were entangled in the substrate making it difficult to collect a complete specimen. In flower it is recognized by its short scape usually less than 6 cm. Our specimens are referable to subsp. *gibba*.

Range: This is the most widespread of all the species of *Utricularia*. In the Great Lakes region (Minnesota, Wisconsin, Michigan, Ohio and southern Ontario) to southern Quebec, New Brunswick and Nova Scotia, south to New England and New York; Tennessee; Oklahoma; along the Pacific coast from southern British Columbia to central California; chiefly the coastal plain from Virginia to Florida and eastern Texas; Mexico; south in South America to Argentina; tropical Africa. *Utricularia gibba* subsp. *exoleta* (R. Brown) Taylor is known from Spain and Portugal; North, tropical, and South Africa; tropical Asia; Australia.

6. *Utricularia cornuta* Michx.   Horned Bladderwort   Map 6
   Stomoisia cornuta (Michx.) Raf.

Terrestrial or aquatic with delicate, subterranean stems, erect, linear-filiform simple branches bearing minute traps; scapes erect, wiry, 3–35 cm tall, mostly 1–3 flowered; corolla yellow, 1.5–2.5 cm high, the larger lower lip helmet-shaped, with projecting convex center and recurved sides; spur subulate, turned down and outward, 7–12 mm long.

Utricularia cornuta is most frequent across the northern quarter of the state where it occurs in open, quaking sedge mats and *Sphagnum* bogs, occasionally sandy shores of soft water lakes, sometimes in such numbers as to make a bog appear golden yellow from a distance. In suitable areas along Lake Superior (e.g., Stockton Island, Ashland County) and Lake Michigan (e.g., Jackson Harbor Ridges, Door County) *U. cornuta* occurs on wet sandy flats and swales at the edge of rear dune beach pools. In the southern quarter of the state it has been found in a few calcareous fens on marl flats or peat. In oligotrophic lakes particularly in Vilas County, Horned Bladderwort occurs in dense, sterile clones on the sandy lake bottoms, flowering only when exposed by a temporarily retreating lake shore.

Range: From Ontario (54 deg. N) and Quebec (Lake Mistassini, Gaspe Peninsula) to Labrador, south chiefly on the coastal plain to Florida and west to eastern Texas, inland south to West Virginia, Ohio, northern Indiana, northeastern Illinois, and Minnesota; West Indies. The range map prepared by Kondo (1972a) omits Minnesota and is incomplete in Ontario and Quebec.

7. *Utricularia vulgaris* L.   Common Bladderwort   Map 7
   Utricularia vulgaris subsp. *macrorhiza* (Le Conte) Clausen
   Utricularia vulgaris var. *americana* Gray
   Utricularia macrorhiza Le Conte

Relatively coarse with prolonged free floating stems, the plumose branches of foliage 3–12 cm in diameter; leaf-like segments elliptic to ovate, much dissected, the coarser capillary segments up to 0.75 mm thick; scapes coarse, 10–80 cm long with 6–20 or more flowers; corolla yellow, 1.5–2.5 cm high, the broad lower lip slightly 3-lobed and shorter than the spur; fruiting racemes elongate with recurved pedicels; winter buds ellipsoid, 1–2 cm long, their compacted branches hairy.

Utricularia vulgaris is the most abundant and frequently observed of our Bladderworts, occurring in quiet waters of many lakes regardless of water chemistry, but especially bog lakes, marshes, and many wetlands with pockets of open water, ditches, ponds, and in sluggish streams and river sloughs. It is absent only from several of the southwestern Wisconsin "Driftless Area" counties and a few northern counties, where its apparent absence is probably due to incomplete collecting.

Common Bladderwort is robust, occasionally to 1 m in length, often found suspended in shallow water on detritus or tangled with other aquatic vegetation, often sterile. Bladder-traps are numerous throughout the plant. Its leaf-like segments are denticulate-bristly with elongate spines (when viewed under magnification) distinguishing it from *Utricularia geminiscapa*, which has spines only on the branch tips.

Range: Alaska to Labrador, south to Florida, Ohio, Indiana, Texas, Arizona, and California; Mexico; nearly throughout Europe and temperate Asia. A map of its world wide range is found in Hulten (1971), map 122.

According to some botanists the length and shape of the spur are different between the new world and some of the old world populations of *Utricularia vulgaris*. However, Taylor (1964) states: "Fernald made a careful comparative study of the European and North American *U. vulgaris* and I am in complete agreement with his findings that they are the same."

8. *Utricularia geminiscapa* Benj.   Map 8
   Utricularia clandestina Nutt.

Free floating and slender, the plumes of foliage 1–3.5 cm in diameter; branches three times dichotomous into capillary segments about 0.25 mm thick, many of them with traps; flowers of two types, cleistogamous apetalous ones on short pedicels from many axils; petaliferous flowers yellow, on filiform peduncles; corolla 5–8 mm high, the larger lower lip 3-lobed, somewhat longer than the thick, blunt spur.

This Bladderwort is infrequent in the central and northern portions of the state in quiet waters of a variety of soft water lakes, boggy marshes, pools, and ditches in cranberry plantations, as well as calcareous beach swales in Door County. Where stranded on beaches or sufficiently near the surface, a multiflowered scape of petaliferous flowers may be produced. Submerged specimens produce cleistogamous flowers on short peduncles.

Utricularia geminiscapa is closest in overall appearance to *U. vulgaris*, although it is more delicate, smaller, and often has cleistogamous flowers.

Range: From Wisconsin and Michigan to southern Quebec (not known from Ontario), Newfoundland, New Brunswick and Nova Scotia, south to New York and Virginia. A range map, now somewhat incomplete, was prepared by Fernald (1933), p. 85.

II. Pinguicula   Butterwort   Not Mapped

9. *Pinguicula vulgaris* L.

Leaves spatulate to elliptical, 2–6 cm long, yellowish-green, greasy and viscid; scape 4–15 mm high; corolla excluding the straight spur, 1–2 cm long, violet, its lips very unequal, its tube funnelform.

Butterwort is a circumpolar species collected in Wisconsin in 1955 from Otter Island (F. C. Lane, #2569, August 5, Northland College Herbarium) and in 1956 from Devil's Island (F. C. Lane, July 31, Northland College Herbarium) from cold, north-facing cliffs in Lake Superior within the Apostle Islands National Lakeshore, Ashland County. Both populations remain undisturbed, the one on Devil's Island the larger, including hundreds of plants, some of which are well above water level in small crevices of the sandstone cliffs.

Range: From Alaska southeastward across the continent to South Baffin Island and northern-most Labrador, south in the Pacific Northwest to northern California, and inland to Idaho, Montana, northern Saskatchewan, northern Minnesota, Michigan, New York, Vermont and New Hampshire; east and west coasts of Greenland; Iceland, northernmost Scandinavia, northern Russia and the northern Ural Mountains, south to Spain, Italy, northern Balkans, and western Russia; also central and eastern Asia. The North American range of *Pinguicula* is shown in Schnell (1976), p. 74; mapped in part in Porsild (1964), p. 198; and in Casper's (1966) monograph after p. 174 (*P. vulgaris*) and p. 178 (*P. macroceras*).

Variations in flower size and spur length have lead to the naming of segregate entities within the Pacific coast and east Asian populations of Butterwort. Some botanists prefer to call these populations *P. macroceras* Link (*P. vulgaris* var. *macroceras* Herder), including *P. microceras* Cham. and others. The exact relationships between these as well as the Asian species are uncertain.

ACKNOWLEDGMENTS

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REVIEW

GUIDE TO THE VASCULAR FLORA OF ILLINOIS, REVISED AND ENLARGED EDITION. By Robert H. Mohlenbrock. 1986. ix + 507 pp. Southern Illinois University Press, Carbondale, Illinois 62902. $42.50 cloth, 16.95 paper.

This book, a second edition of the original "Guide" published in 1975, consists, like the first edition, of keys to all species known from Illinois, and very brief entries for each species giving habitat, flowering time, distribution in Illinois, and synonymy. An introductory section covering the physiography and vegetation of Illinois prefaces the taxonomic treatment. On the whole, this book is a bit of a disappointment. It should be a good deal, given the astronomical price of the author's "Illustrated Flora of Illinois" series, but it fails to live up to its full potential. Allegedly revised and enlarged; I was able often only to detect enlarging. An additional 157 taxa are treated, so the book is more complete. The text and keys have been altered accordingly, but as far as revising treatments to update them goes, the book is often lacking. Errors in the first edition, such as the mis-application of the name *Xyris jupicai* to Illinois plants that should be called *X. difformis*, persist in this edition. The incorrect name *Calamagrostis neglecta* is used—even though this species is evidently a recent addition. The treatment of *Carex* is essentially identical to the previous edition—it has in fact shrunk by one species—in spite of considerable systematic work on the genus in the past decade. The treatments of *Salix* and *Silene* are also quite dated.

Some updating has occurred. An up-to-date treatment of *Cystopteris* was contributed by Robbin Moran. The treatment of the difficult genus *Panicum* has been redone. The Orchidaceae have been revised. Updating, however, has been spotty.

This book is a good source for finding out what plants grow in Illinois. It is not a good source for making sure you have the correct name for the plant. For that, one must check other literature. A little more work could have made this a much more useful book.

A. A. Reznicek

HYBRIDIZATION IN MICHIGAN WHITE OAKS (QUERCUS SUBG. LEPIDOBALANUS) WITH EMPHASIS ON TWO NEW HYBRIDS

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Two undescribed hybrid oaks in subg. *Lepidobalanus* are reported: 1) *Quercus macrocarpa* Michx. (Bur oak) × *Q. prinoides* Willd. (Dwarf chinkapin oak), and 2) *Q. bicolor* Willd. (Swamp white oak) × *Q. prinoides*. Interspecific hybridization within the two eastern oak subgenera is common and well documented (Bartlett 1951; Benson et al 1967; Cooperrider 1957; Cottam et al 1982; Hardin 1975; Leydig et al 1969; Maze 1968; Muller 1952; Ness 1918, 1919, 1927; Palmer 1948; Piatnisky 1960; Stebbins et al 1947; Thomson 1977; Trelease 1917, 1924; Tucker 1952, 1953, 1961, 1963, 1970; Tucker & Bogert 1973; Tucker et al 1961; Wagner & Shoen 1976; Wolf 1944). However, intersubgeneric hybridization in nature has not been reported, although these hybridizations have been artificially induced (Ness 1919; Piatnisky 1960; Cottam et al 1982).

MATERIALS AND METHODS

Collections of two hybrids were made in October 1981. Ten representative samples of *Q. bicolor* and *Q. macrocarpa* were chosen from the University of Michigan Herbarium to represent these species. The taxonomic status of the two chinkapins, *Q. prinoides* and *Q. muehlenbergii*, has been a source of debate and confusion. To ensure that normal *Q. prinoides* types were used, I collected 10 typical examples from a single population in Washtenaw County (R4E, T1S: Dexter Twp., Sec. 5; E. of Hankard Rd., near Noah Rd.). *Quercus prinoides* is highly variable, and I attempted to buffer the effects of within-plant heterophylly by using a sample of 20 leaves per plant. Often the desired number was not available because of herbivory and disease, but it rarely dropped below 15 leaves per individual. Field observations showed that the second, third, and fourth leaves from the terminal bud were relatively uniform and representative. Because most individuals were represented by a single sheet in the herbarium, 3 leaves per individual were used for *Q. bicolor* and *Q. macrocarpa*.

The plants were scored for 17 characters (described below). The initial matrix was 17 columns (variables) by 360 rows (leaves). The character states for each individual were averaged and the matrix was reduced to 17 characters by 35 individuals.

Habit: 1) shrub: with at least 10 basal stems, frequent stem suckering, and a low, spreading, clonal form; 2) intermediate: with 3 to 10 basal stems, infrequent suckering, and intermediate in form between shrub and tree; 3) tree: with 1, or sometimes 2, basal stems, rare suckering and usually a large spreading crown. *Lamina length* was measured from where the petiole meets the blade along the midrib to the apex (Fig. 1, line A). This and all other non-integral variables were recorded to the nearest 0.1 cm. *Petiole length* was measured from the point of abscission to where the petiole meets the blade (Fig. 1, line B). *Lamina width* was measured perpendicular to the midrib at the widest point of the blade (Fig. 1, line C). *Number of major secondary veins*: I arbitrarily counted only veins on the right hand side of the abaxial surface of the leaf. *Number of leaf lobes*: Only major teeth from the right side of the leaf, excluding the terminal lobe, were included. *Leaf margins* ranged from almost entire in some shrubs to repand, sinuate, crenate, and deeply lobed in some large trees. This character
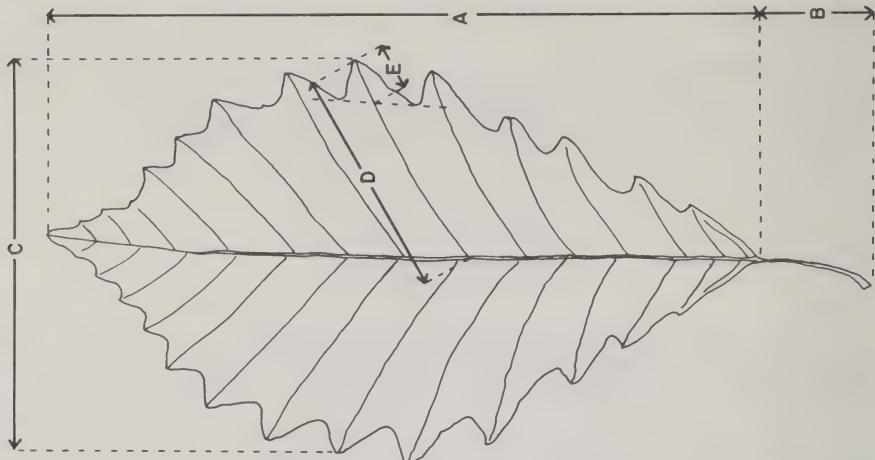
Fig. 1. Measurements for lamina length (A), petiole length (B), lamina width (C), length of longest major secondary vein (D), length of longest lobe (E), indentation index (D/E).

was treated as a quantitative multistate character because the character states could be divided into an obvious logical order. The character states were coded into 5 evenly-spaced class intervals, 1 through 5. *Leaf base shape* was also treated as a quantitative multistate character with the character states divided into five intervals. Five angles, 40°, 55°, 70°, 85°, and 100°, were drawn on a 5 × 11 in index card. The leaf was then placed so that the point of petiole-lamina attachment was superimposed on the vertex of the angle. The leaf was given a score of 1 through 5 based on the angle it approximated the closest. *Length of the longest vein* was measured from the midrib to the tooth end on the right-hand side of the abaxial surface of the leaf (Fig. 1, line D). *Length of the longest lobe*: A 3 × 5 in index card was placed on the leaf blade creating a line connecting the sinus above and the sinus below the longest lobe. The measurement was then made from the tip of the lobe to the edge of the index card (Fig. 1, line E). *Lamina length/ lamina width*: The length of each leaf was divided by the width to give a value describing leaf shape (Fig. 1, line A/C). *Lamina length/ petiole length*: (Fig. 1, line A/B). *Vein/ lobe*: The number of major secondary veins was divided by the number of lobes. *Vein length/ tooth length*: An index which describes tooth length independent of leaf size. This character reflects the ''relative'' size of the longest lobe and is referred to as an indentation index (Fig. 1, line D/E). *Longest tooth position/ number of major secondaries*: I assigned a numerical value to leaf shape by dividing the position of the longest major secondary vein, counting from the first major secondary vein at the base of the leaf, by the total number of secondary veins.

   Foliar trichomes: Foliar trichome structure in the taxonomy of oaks was used by Engelmann (1877), Sargent (1918), Trelease (1924), and Dyal (1936). Trichome morphology was increasingly used in delimiting species and recognizing oak hybrids (Camus 1934–54; Palmer 1948; Tucker 1952, 1963, 1970; Tucker et al 1961; Hardin 1975). With scanning electron microscopy researchers observe *Quercus* trichome morphology *in situ* (Hardin 1976, 1979a, 1979b, 1979c; Thomson & Mohlenbrock 1979; Nixon & Steele 1981, Cottam et al 1982). I have used Hardin's (1976) concise classification of *Quercus* trichome types.

   Initially, all of the leaves collected from each individual were examined under the dissecting microscope at 90 × magnification. The types present on each individual were recorded. Then I selected five representative leaves from each individual for further study. The area on the leaf halfway between the base and apex and between midrib and margin on the abaxial surface of the leaf was used. The number of rays per stellate trichome and the length of the longest ray were recorded for two stellate trichomes from each of five leaves, for a total of 10 trichomes per individual. To avoid bias, those trichomes closest to 0 and 100 on the superimposed ocular micrometer were chosen. Scanning electron micrographs were prepared to illustrate typical trichome types. Small squares (*ca.* 5 mm^2) were cut from the leaf surface and then mounted abaxial surface upward on an aluminum stub

1 cm in diameter. The stubs were coated with 200 Å of gold. A JEOL JSM-U3 scanning electron microscope at 15 kv was used. Photomicrographs were taken with Polaroid positive/negative 4 × 5 land film, type 55.

Both pictorialized scatter diagrams (PSD) and principal components analysis (PCA) were used in the final numerical analysis. *Pictorialized scatter diagrams*: Anderson's (1949) techniques have enjoyed wide and common usage. Several authors, including Tucker (1952), Tucker et al. (1961), Tucker (1970), Hardin (1975), and Thomson (1977), have used pictorialized scatter diagrams in studies of oaks to show extent of intermediacy of hybrids between putative parents. Although Anderson's PSD's have been used extensively, their inherent biases have come under attack (Wells 1980, 1981). By choosing different variables to represent the ordinate and abscissa, the taxonomist can change the way in which the data are presented. This subjectivity makes the PSD's "non-scientific." Maze (1980) argued that these biases serve to support arguments for well-defined hypotheses: "Anderson techniques are designed to be used with knowledge." The controversy over the use of PSD's sparked my use of principal components analysis.

Principal components analysis: The use of principal components to represent objects in space assumes that a variable with large variance is more useful in distinguishing between objects than is a variable with a small amount of variance. Variance is assumed to be analogous to information content. This study made use of the principal components program written by Estabrook (1976). The first, second, and third principal components were computed and plotted as a three-dimensional spatial representation of variation to show intermediacy of hybrids between putative parents. Ten representative individuals of *Q. prinoides* were plotted against ten of *Q. bicolor* and *Q. macrocarpa* with their respective hybrids on three separate plots.

RESULTS

Quercus × *beckyae* Gaynor (*Q. macrocarpa* Michx. × *prinoides* Willd.) hybrida nova.

Frutices clones formantes. Folia 13–16 cm longa, 7–8 cm lata, utrinque 8–11 lobis instructa, lobo longissimo 1–2.5 cm longo, 1 sinu plerumque paene usque ad costam extenso, 10–13 venis secundariis majoribus instructa, vena longissima 4.5–5.5 cm longa, trichomist stellatis, fasciculatis, simplicibus, et solitariis instructa. Petioli 1–2 cm longi. Glandes 1–2 cm longae, 1–2 cm latae, squamis cupulae conspicue fimbriatis.

Shrubs showing stem sprouting, becoming clonal, 1–2 m in diameter, 1–2 m high. Leaves densely pubescent when immature, becoming green to olive and glabrate above, remaining whitish and pubescent below, oblong to obovate, base cuneate or sometimes rounded, apex acute approaching acuminate, 13–16 cm long, 7–8 cm wide, 8–11 lobes per side, with the same number or slightly more major secondary veins, usually with 1 sinus extending farther towards the midrib than any other dividing the leaves into broader, upper, and narrower, lower, portions as in *Q. macrocarpa*. Longest major secondary vein 4.5–5.5 cm long, longest lobe 1–2.5 cm. Petioles 1–2 cm long. Leaves with stellate, fasciculate, simple and solitary trichome types; stellate trichomes with 6–8 rays, longest ray 0.115–0.195 mm long. Acorns 1–2 cm long, 1–2 cm wide, scales of the cup with conspicuous fringe, cup enclosing 1/2 to 3/4 or more of the nut, peduncles obsolete to 1 cm. Type: Michigan: Livingston Co., Hamburg Twp., R5E, T1N, Sec. 2, adjacent to Bishop Lake Rd., 0.5 mi W. of Bauer Rd., *Gaynor 81B21* (Holotype, MICH). The name *Q.* × *beckyae* commemorates Rebecca J. Hale, who was instrumental in collecting this hybrid.
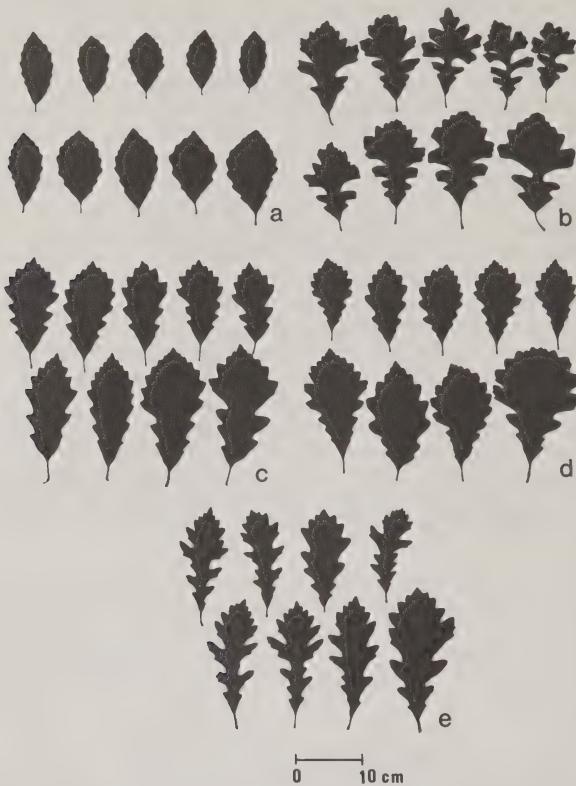
Fig. 2. Silhouettes of leaves from (a) *Q. prinoides*, 81023, (b) *Q. macrocarpa*, 82013, (c–e) *Q.* × *beckyae*, 81B21, 81B16, 81B22 respectively.

The hybrids were easily recognized by their large leaves and their approach to a "wasp-waist" type of lamina morphology (Fig. 2c and Fig. 2d). The hybrids produced what appear to be viable acorns that were intermediate in size, shape, and texture; the fringe-like protuberances on the cup were particularly diagnostic (Fig. 3). One plant is a putative backcross to *Q. macrocarpa*, as the leaves show further morphological approach to *Q. macrocarpa* in most characters, especially leaf length, width, and degree of marginal indentation (Fig. 2e). The fact that both hybrids and the backcross were shrub-like in habit further suggested the genetic influence of *Q. prinoides*. The plants were found in a disturbed habitat adjacent to a dirt road. *Quercus prinoides* was relatively abundant, while *Q. macrocarpa* was rare.

Quercus prinoides possessed mostly stellate trichomes (Fig. 4a), although fasciculate and solitary trichomes were also observed often. Simple trichomes were rare to infrequent. *Quercus macrocarpa* had approximately equal numbers of stellate and fasciculate trichomes and was usually densely pubescent (Fig. 4c). One of the most diagnostic characters for *Q. macrocarpa* was the presence of a conspicuous, long-rayed, wavy, fasciculate trichome; *Q.* × *beckyae* had this
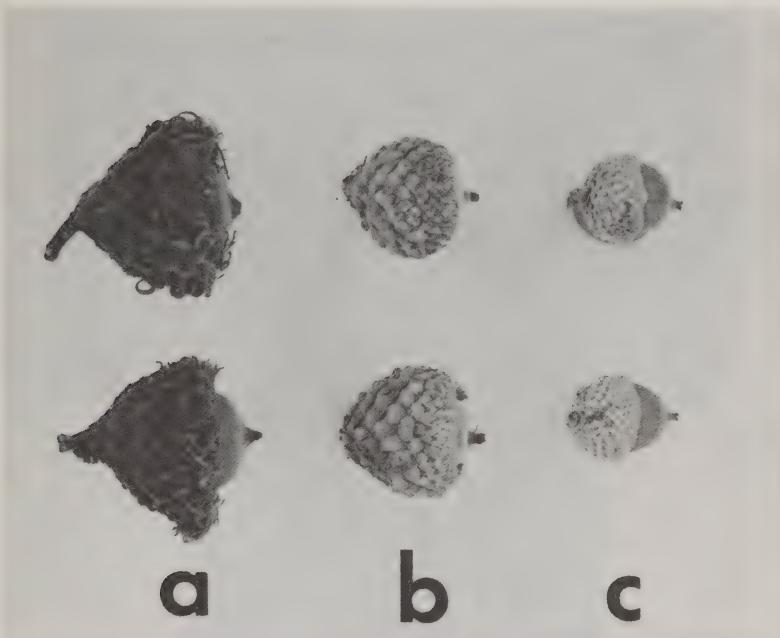
Fig. 3. Acorns of (a) *Q. macrocarpa*, 82013, (b) *Q.* × *beckyae*, 81B21, (c) *Q. prinoides*, 81023. Actual size.

trichome but also numerous *Q. prinoides*-like stellate trichomes (Fig. 4b). In addition, *Q.* × *beckyae* trichomes were much less dense than those of *Q. macrocarpa*. Both parents and hybrids had conspicuous scaly epicuticular wax deposits on the abaxial lamina surface beneath the trichomes.

In both the PSD (Fig. 5, Table 1) and PCA (Fig. 6, Table 2), the hybrids appeared intermediate in morphology. In the PSD, the putative backcross to *Q. macrocarpa* showed an approach to that parent. Likewise, in the PCA plot, the backcross was closer to individuals of *Q. macrocarpa* than were the hybrid individuals. The first three principal components accounted for 73% of the observed variance (Table 2). The first was weighted on almost equal amounts of lamina width, lobe length, indentation index, and vein length. The second and third were weighted on tooth shape and lamina length/ petiole length, respectively.

Quercus × *wagneri* Gaynor (*Q. bicolor* Willd. × *prinoides* Willd.) hybrida nova.

Frutices clones formantes. Folia 10–13 cm longa, 5–6 cm lata, utrinque 6–8 lobis obtusicrenatis vel sinuatis instructa, lobo longissimo 0.6–0.8 cm longo, 8–10 venis secundariis majoribus instructa vena longissima 3–4 cm longa, trichomes stellatis, fasciculatis, simplicibus, et solitariis instructa. Petioli 1.4–1.7 cm longi. Pedunculi 0.5–2.5 cm longi. Glandes 1.5–2.5 cm longae, 1–2 cm latae.

Fig. 4. Scanning electron micrographs of foliar trichomes of (a) *Q. prinoides*, stellate trichomes, X200 (81208), (b) *Q. × beckyae*, stellate and fasciculate trichomes, X200 (81B16), (c) *Q. macrocarpa*, dense long fasciculate trichomes covering shorter-rayed stellate trichomes, X200 (81600).

Clonal shrubs, 1 m in diameter, 2 m in height. Leaves dark green above, pale-white to bone-colored below, obovate-oblong to oval, base rounded, cuneate, or occasionally truncate, apex acute, 10–13 cm long, 5–6 cm wide, 6–8 blunt-crenate to sinuate lobes per side, with usually slightly more major secondary veins. Longest major secondary vein 3–4 cm, longest lobe 0.6–0.8 cm. Petioles 1.4–1.7 cm long. Leaves with stellate, fasciculate, simple and solitary trichome types; stellate trichomes with 7–9 rays, longest ray 0.09–0.10 mm. Acorns 1.5–2.5 cm long, 1–2 cm wide, peduncles 0.5–2.5 cm long, cup enclosing 1/3 to 1/2 of the nut. Type: Michigan: Livingston Co., Hamburg Twp., R5E, T1N, Sect. 2, adjacent to Bishop Lake Rd., NE. of Bishop Lake, 1.2 mi. W. of Bauer Rd., *Gaynor 81B14* (Holotype, MICH). The name *Q. × wagneri* commemorates W. H. Wagner, Jr. who was instrumental in the collection of this hybrid.

Washtenaw Co. collections of *Q. wagneri* were made by Burt E. Quick, June 22, 1913 (labled *Q. prinoides*) and E. B. Mains, June 22, 1913 (labeled *Q. bicolor*) and were deposited in MICH. The plants were collected on the same day; Quick and Mains most likely collected the same plant and disagreed on its
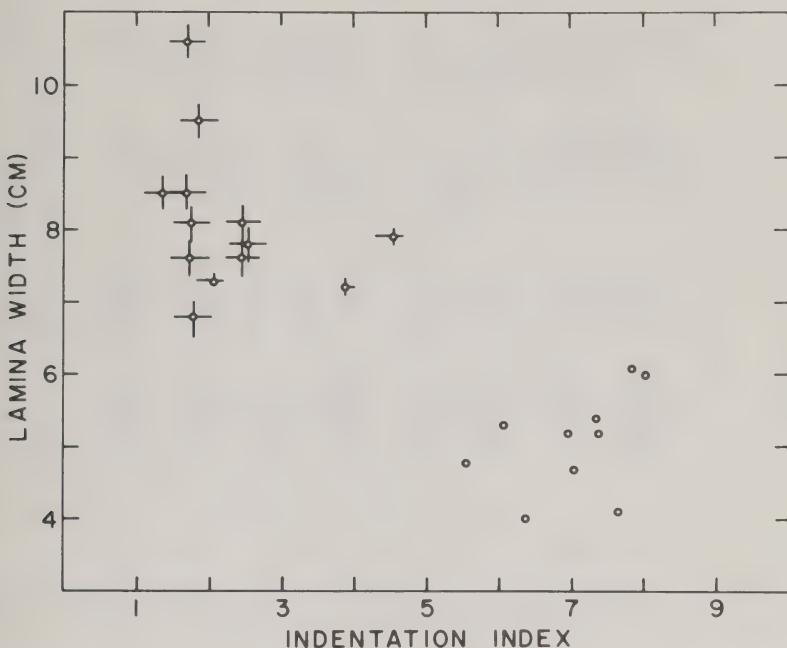
Fig. 5. Pictorialized scatter diagram showing *Q. macrocarp* ', ᵔ × *beckyae*, and *Q. prinoides*. (See Table 1 for symbols.)

TABLE 1. Symbols used in the pictorialized scatter diagram of *Q. prinoides*, *Q. × beckyae*, and *Q. macrocarpa*, with range of values for quantitative characters.

Character	prinoides	X beckyae	macrocarpa
Habit	o (Shrub)	ᶞ	↓ (Tree)
Presence/Absence of Acorn Cup Fringe	o (absent)	o—	o— (Present)
Lamina Length/ Lamina width	o (> 2.0 cm)	♀ (2.0–1.7 cm)	↑ (<1.7 cm)
Lamina Length	o (≤10.9 cm)	—o (11–12 cm)	—o (≥12.1 cm)

parentage. Both specimens had whitish-pubescent abaxial leaf surfaces with dense stellate and fasciculate trichomes.

Figure 7 shows leaf silhouettes; Figure 7d shows asymmetrical lamina morphology characteristic of hybrids. The hybrids are recognized by their intermediate acorn, particularly in size of nut and length of peduncle (Fig. 8). A
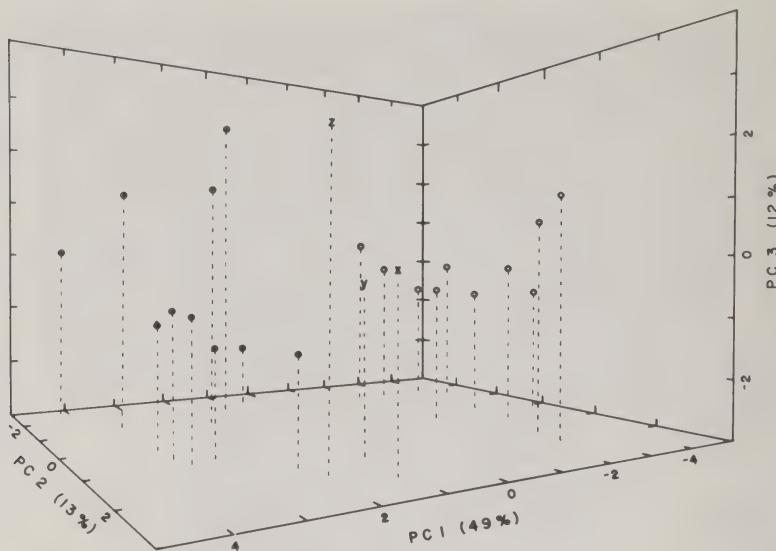
Fig. 6. Perspective principal components plot of *Q. macrocarpa* (solid circles), *Q.* × *beckyae* (x = 81B26, y = 81B21, z = 81B22), and *Q. prinoides* (open circles).

TABLE 2. Absolute eigenvalues and their contribution to total variation (*Q. macrocarpa* × *prinoides*).

Principal Component	Eigenvalue	% of Total Variation	Cumulative % of Variation	Variates Contributing
1	8.325	49.0	49.0	Lamina width, Indentation index, Lobe length, Vein length
2	2.190	12.9	61.9	Tooth shape
3	1.963	11.5	73.4	Lamina length/Petiole length

distinguishing characteristic of *Q. bicolor* is the downy, white pubescence on the abaxial leaf surface. *Quercus* × *wagneri* had this white pubescence, but not as pronounced as that in *Q. bicolor*. The two hybrids were found along a road, adjacent to a swamp and occupied habitats that were intermediate and probably disturbed by the construction of the road. Both parents were present, although *Q. prinoides* was much more abundant.

Quercus bicolor possessed both stellate and fasciculate trichomes (Fig. 9c). The conspicuous, long-rayed, fasciculate, trichomes often found on *Q. macrocarpa* were also common on *Q. bicolor*. In addition, Q bicolor was distinctive in that it lacked the scaly epicuticular wax deposits present on both *Q. prinoides* and *Q. macrocarpa*. *Quercus* × *wagneri* possessed the shorter stellate trichomes and the scaly epicuticular wax deposits of *Q. prinoides* and the long-rayed, fasciculate trichomes of *Q. bicolor* (Fig. 9b).
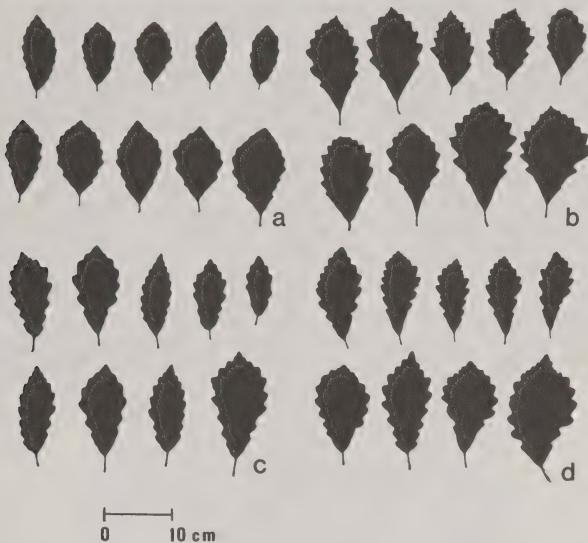
Fig. 7. Silhouettes of leaves from (a) *Q. prinoides*, 81023, (b) *Q. bicolor*, 81109, (c–d) *Q. × wagneri*, 81B14, 81B13, respectively.

Fig. 8. Acorns of (a) *Q. bicolor*, 81109, (b) *Q. × wagneri*, 81B14, (c) *Q. prinoides*, 81023. Actual size.
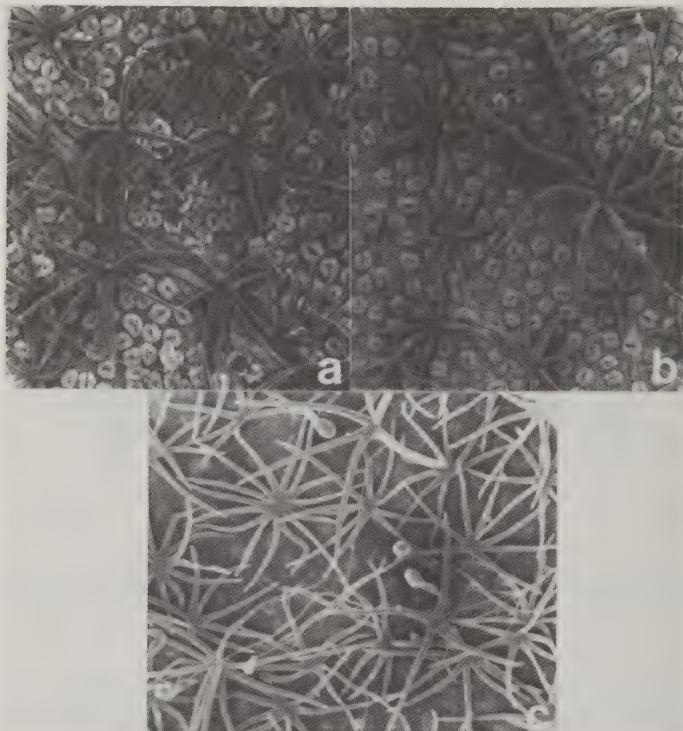
Fig. 9. Scanning electron micrographs of foliar trichomes of (a) *Q. prinoides*, stellate trichomes, X200 (81203), (b) *Q.* × wagneri, stellate and fasciculate trichomes, X200 (81B14), (c) *Q. bicolor*, dense stellate and fasciculate trichomes, X200 (81109).

The hybrids appear intermediate in the PSD (Fig. 10, Table 3) and in the PCA (Fig. 11, Table 4). One hybrid (81B14) showed a slight departure from intermediacy along the axis of the second principal component, although it was intermediate along the axis of maximum variance. The first three principal components accounted for 73% of the observed variance (Table 4). The first was weighted on lamina length, vein length, lobe length, and lamina width. The second and third were weighted on base shape and number of lobes, respectively.

DISCUSSION

In a syngameon where genetic exchange is widespread via introgression and hybridization, each species is able to gain access to the common gene pool of the syngameon, and this exchange eventually contributes to the variability and adaptability of the participating species (Anderson 1949). Recognition of hybrids in such a situation is difficult because many F_1 crosses backcross or introgress to the parental species, and other species of the syngameon.

Leaves of four species of the *Lepidobalanus* syngameon and their hybrids are depicted in Figure 12. The corresponding hybrids of *Q. muehlenbergii* (not
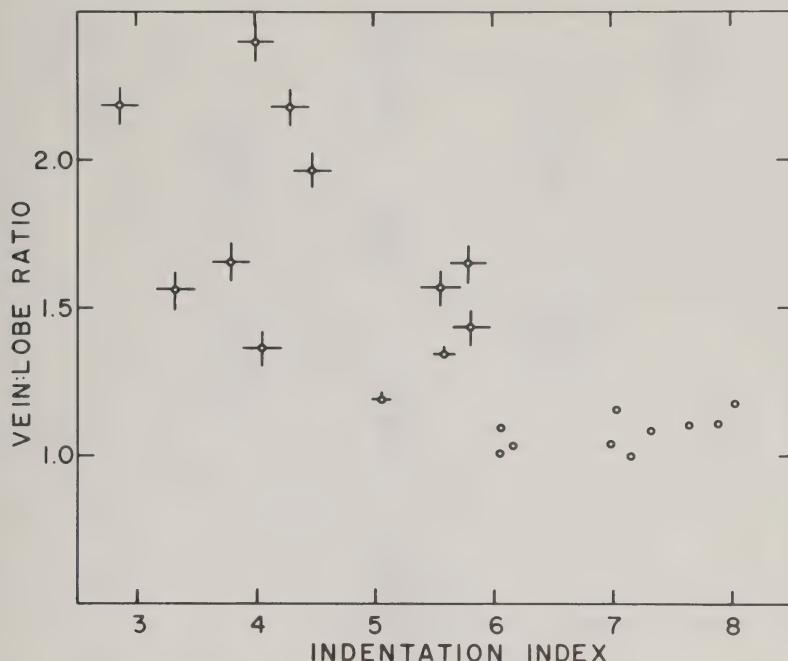
Fig. 10. Pictorialized scatter diagram showing *Q. bicolor*, *Q.* × *wagneri*, and *Q. prinoides*. (See Table 3 for symbols.)

TABLE 3. Symbols used in the pictorialized scatter diagram of *Q. prinoides*, *Q.* × *wagneri*, and *Q. bicolor*, with range of values for quantitative characters.

Character	prinoides	X wagneri	bicolor
Habit	o (Shrub)	♂	♀ (Tree)
Peduncle Length	o (<0.5 cm)	o— (0.5–2.0 cm)	o— (>2.0 cm)
Lamina Vestiture	o (Epicuticular wax present)	⚲	⚱ (Epicuticular wax absent)
Habitat	o (Uplands)	—o	—o (Swamps)

shown) are quite similar to those of *Q. prinoides*, as would be expected, however, the leaves are somewhat larger and the plants are trees, not shrubs. The intrinsic variability and ecological preferences of the parental species makes the location of true hybrids fairly easy. First generation hybrids are intermediate in morphology and occupy intermediate habitats (Anderson 1948). Following is an
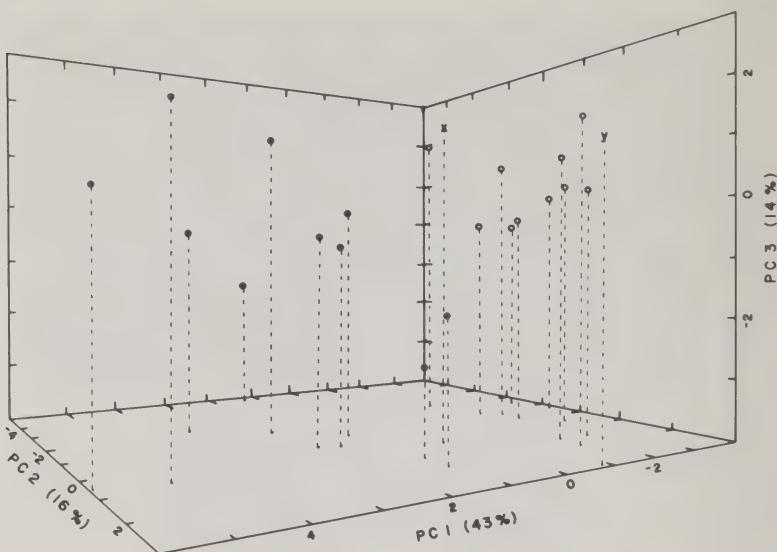
Fig. 11. Perspective principal components plot of *Q. bicolor* (solid circles), *Q.* × *wagneri* (x = 81B13, y = 81B14), and *Q. prinoides* (open circles).

TABLE 4. Absolute eigenvalues and their contribution to total variation (*Q. bicolor* × *prinoides*).

Principal Component	Eigenvalue	% of Total Variation	Cumulative % of Variation	Variates Contributing
1	7.359	43.3	43.3	Lamina length, Vein length, Lobe length, Lamina width
2	2.760	16.2	59.5	Base shape
3	2.320	13.6	73.1	Number of lobes

alphabetical listing of all of the *Lepidobalanus* (white oak) hybrids that are now known to occur in Michigan: *Q. alba* × *bicolor* = *Q* × *jackiana* Schneider; *Q. alba* × *macrocarpa* = *Q.* × *bebbiana* Schneider; *Q. alba* × *muehlenbergii* (not *Q.* × *deamii* Trelease); *Q. alba* × *prinoides* = *Q.* × *faxonii* Trelease; *Q. bicolor* × *macrocarpa* = *Q.* × *hillii* Trelease; *Q. bicolor* × *prinoides* = *Q. wagneri* Gaynor; *Q. macrocarpa* × *muehlenbergii* = *Q.* × *deamii* Trelease; *Q. macrocarpa* × *prinoides* Gaynor = *Q. beckyae* Gaynor; *Q. muehlenbergii* × *prinoides*. Although the last hybrid and its presumed backcrosses occur often in nature they still remain undescribed. Often gradation from one parent into the other appears to be continuous. We are currently studying these.

　　Transgressive segregation could explain extreme character states of putative hybrids, although introgression to a third or even a fourth species would also explain this. Tucker (1970) described the lack of intermediacy in some characters
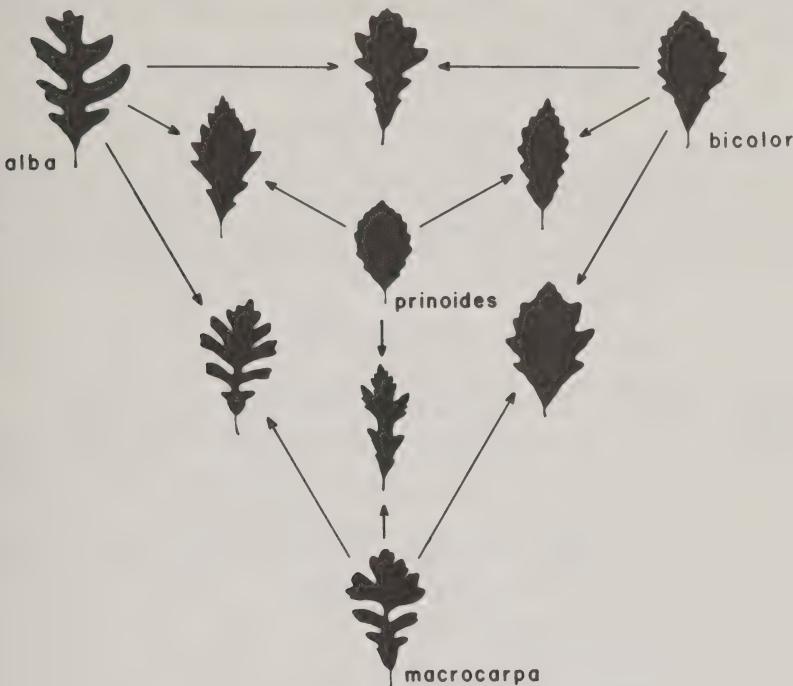
Fig. 12. Four species of Lepidobalanus syngameon with hybrids.

of hybrids between *Q. gambelii* and *Q. havardii* within the *Q. undulata* complex in the western U.S. as a result of past introgression by *Q. turbinella*.

The dominance of one parent over the other in a character, discussed above, may explain morphological anomalies observed in oak hybrids. Asymmetric leaf shape is useful in identifying hybrid plants and this has been described in oaks of the red oak group (Wagner & Schoen 1976) and ferns (Wagner 1962). Dominance of one parent over the other can create "lopsided" intermediates (Wagner 1969).

It has been suggested that much oak hybridization is a result of recent disturbance by man. Hybrids and introgressants are often found on man-made sites. However, Britton's (1886) description of hybridization between *Q. prinoides* and *Q. muehlenbergii* 100 years ago is very similar to present day patterns. In addition, Maze (1968) suggested that relict hybrids found in New Mexico, South Dakota, and Wyoming between *Q. macrocarpa* and *Q. gambelii*, two currently allopatric species, were the result of past westward migration of *Q. macrocarpa* during pluvial periods of the Pleistocene. Moreover, it has been suggested that instances of *Q. gambelii* × *turinella* hybrids in Utah, approximately 250 miles north of the current *Q. turbinella* distribution, were the result of past unions of the two species during northerly migrations of *Q. turbinella* in the post-Pleistocene Altithermal age (Cottam et al., 1959; Tucker & Bogert, 1973; Cottam et al., 1982). Thus, interspecific hybridization and introgression

were occurring long before disturbance by man and the "oak problem" is probably not a new one.

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RELATIONSHIPS BETWEEN THE VEGETATION TENSION ZONE AND SOILS DISTRIBUTION ACROSS CENTRAL LOWER MICHIGAN*

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The "tension zone" in the central lower peninsula of Michigan is a south-north change in vegetation from a predominantly deciduous forest to one characterized by a mixture of deciduous and coniferous trees. Like "tension zones" elsewhere, this one separates two vegetation associations with species from either association attaining dominance in response to local site factors. Several authors have described this abrupt transition across central Lower Michigan in their discussion of forest associations, (e.g., Nichols 1935; Braun 1957), while others have addressed its possible causes. Livingston (1903, 1905) concluded that both the northward increase in coniferous species in Kent County and the distribution of coniferous species in Roscommon County may be attributed to the local pattern of coarse-textured surficial material, whereas Potzger (1948) emphasized the importance of climatic control when he identified former northward and southward shifts in the location of the tension zone. Related research has examined the presettlement and/or present forest distribution within the region (e.g., Elliot 1953; Hushen et al., 1966; Kapp 1978) and suggested possible correlations with abiotic (e.g., soils) and biotic (e.g., succession) factors, or has identified a floristic tension zone based specifically on plant ranges (e.g., Kapp 1978; McCann 1982, and Brewer 1982).

Absent from this prior research has been a regional quantitative analysis of the distribution of soils from south to north and the spatial association between soils and vegetation across the tension zone. Veatch (1953, 1958) clearly depicts a correspondence between an increased occurrence of needleleaf tree species and coarse-textured soils northward. Maps depicting the water holding capacity of the upper soil profile (Schneider & Erickson 1967) reveal a northward trend toward lower values. Coarse soil texture is associated with a low water holding capacity, as well as low nutrient availability and low pH, and in sum may be an important controlling factor in plant distribution (Eyre 1968; Daubenmire 1962).

These prior studies concerning regional phytogeography and the northward trend in certain soil characteristics suggest an association between coarse-textured soils and the abrupt increase in the occurrence of needleleaf trees across central lower Michigan. We hypothesized, first, that presettlement forest composition, defined by the number of individuals of representative tree species,
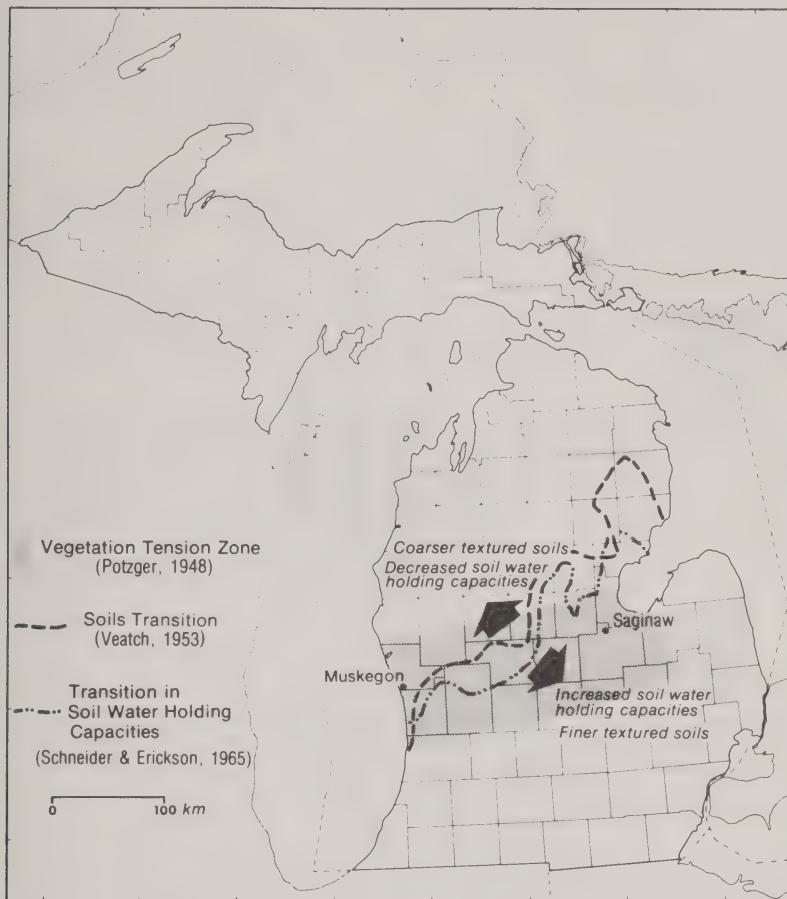
Fig. 1. The study area.

is significantly associated with soil texture, and, second, that the extent of upland coarse-textured soils increases significantly northward across the tension zone. To examine these hypotheses, we measured the degree of spatial association between needleaf evergreen trees, as compared to certain deciduous trees, and soil texture categories, and the northward gradient in coarse-textured soils. From these results we were able to clarify the site specificity of needleaf trees to coarse-textured soils and the increase in these soils northward across the tension zone.

METHODS

The Study Area

As defined in this analysis, the Michigan tension zone extends fifty kilometers on either side of a line from Saginaw to Muskegon (Fig. 1), similar to that drawn by Potzger (1948). This zone
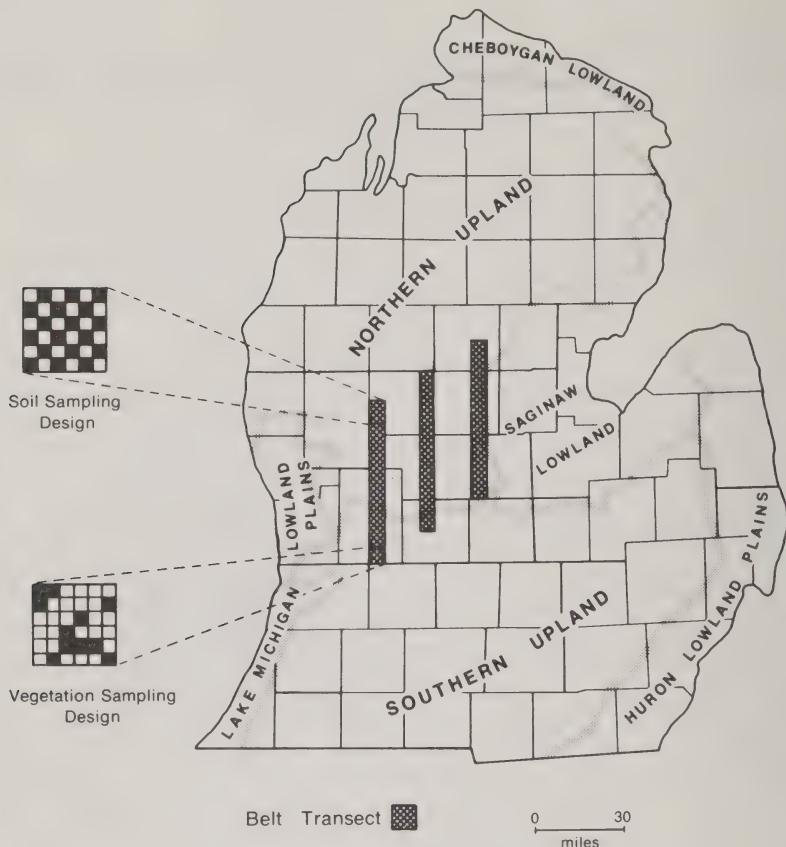
Fig. 2. Location of the belt transects (A, B, C east to west) and the sampling design.

coincides with a northward transition toward coarser-textured soils (Veatch 1953) and upper soil profiles with lower water holding capacities (Schneider & Erickson 1967).

The Sampling Design

Data were collected from the Congressional Land Survey notes (1831–1956, for presettlement forest composition) and from the modern county soil surveys (1960–1984, for soil mapping units) along three 9.6 kilometer-wide belt transects extending south to north across the upland physiographic region of central Lower Michigan (Fig. 2). Forest composition was reconstructed through the tabulation of the name and location of witness and bearing trees. Rather than considering the actual soil mapping units, we recorded the respective management units that are determined by the texture of the upper soil profile (Mokma 1982). Soil texture and associated forest composition data were obtained for zonal mineral soils only, excluding organic, recent alluvial, and bedrock soils because they are localized and maintain a vegetation composition not characteristic of the regional pattern.

The sampling unit from which tree and corresponding soil management unit data were recorded was one section in size, and along each transect a stratified random sample of at least one section per

TABLE 1. Tree species categories and soil texture classes used in the statistical analyses.

Tree Species Categories	Soil Texture Classes	
Beech	Texture 2	clays, silt loam, loam
Sugar Maple	Texture 3	sandy loam
Oak (Red, Black, White)	Texture 4	loamy sand
Pine (White, and others)	Texture 5	sand
Hemlock	Texture c/f	coarse soils over fine
Tamarack (including Cedar)		
Others (trees assumed to prefer mesic habitats: Elm, Ash, Basswood, Red Maple)		

stratum was obtained (see "vegetation sampling design" in Fig. 2). Consequently, the number of trees recorded for a transect varied between transect **A** (1089), **B** (1161) and **C** (1246). Also, to examine the northward trend toward coarse-textured soils, we developed a separate stratified systematic sample of sections and recorded the soil management unit at 0.4 kilometer intervals west-east and south-north within each sampled section (see "soil sampling design" in Fig. 2). To ensure sufficient frequencies for statistical analysis, it was necessary to combine some trees with assumed similar habitats and soil management units of similar textural characteristics (Table 1).

Data Analyses

Data relating tree species categories to soil textural classes were averaged for the three transects and graphed to show the frequencies (as percentages) of certain tree species categories on each soil texture class and the frequencies of all tree species categories on representative fine and coarse texture classes. The association between tree species categories and soil texture classes was analyzed using the chi square statistic (statistical significance), Cramer's V index (strength of the association), and the asymmetric lambda index (predictability of the dependent variable, tree species) (Winkler & Hays 1975; Nie et al 1975).

From scattergrams we subjectively identified a sharp increase northward in the occurrence of coarse-textured soils (texture 4 or 5) and used the t-test to determine the statistical significance of that increase (Nie et al 1975). Regression analyses depicted the linear trend in the occurrence of the most coarse-textured soils (texture 5) northward along each transect, and by incorporating a dummy variable into the equation ($D = 1$, north; $D = O$, south) we determined the differences in the trend north and south of the identified sharp increase in that soil texture class (Nie et al 1975; Johnson 1972. The final regression equation was as follows:

$$y = a + b_1X + b_2D_1 + b_3D_2X$$

where **y** is the frequency of soil texture 5, **a** is the y-intercept, **X** is the distance northward along the transect, D_1 is an additive dummy, and D_2 is a multiplicative dummy (see Medley 1985).

RESULTS

Relationships among Tree Species Categories and Soil Texture Classes

Several overall patterns are evident in the distribution of certain tree species categories on all soil textures (Fig. 3a) and in the distribution of all tree

a.

b.
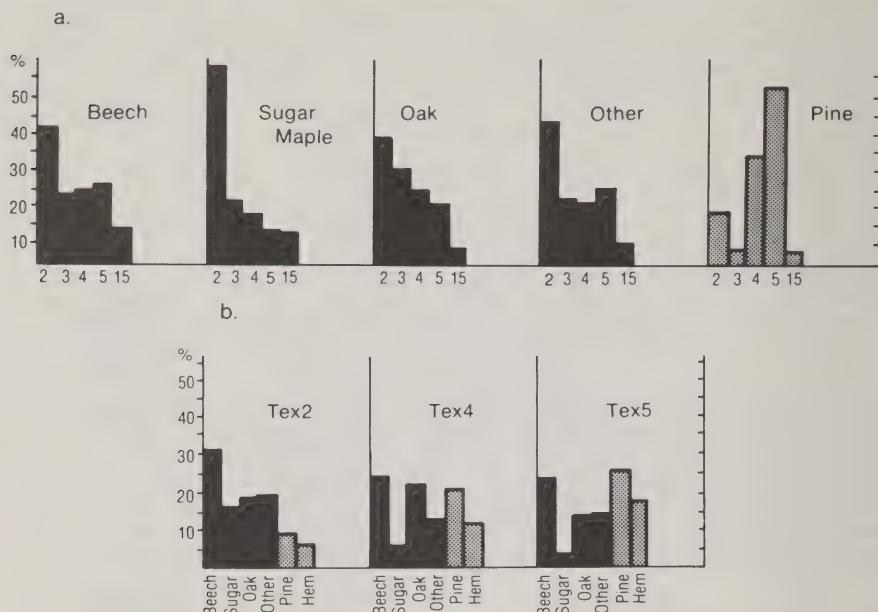
Fig. 3. Frequency percentages averaged from the three transects. a. Distribution of tree species or species categories on all soil texture classes. b. Distribution of all tree species or species categories on representive fine and coarse-textured soils.

species categories on representative fine and coarse-textured soils (Fig. 3b). Beech (*Fagus grandifolia* Ehrhart), oak (*Quercus* spp.), and other mesic deciduous species, although most frequent on soil texture 2, were generally abundant on all soil texture classes. Sugar maple (*Acer saccharum* Marshall) was primarily located on fine-textured soils (soil texture 2), whereas pines and hemlock (*Tsuga canadensis* (L.) Carriere) were most frequent on coarse-textured soils, particularly texture 5 (Fig. 3a). Beech was the most frequent tree on both fine (texture 2) and coarse-textured (texture 4 or 5) soils, exceeded only slightly by pine on soil texture 5, and the frequency of needleleaf species, relative to the other deciduous species, increased noticeably on the coarser-textured soils (Fig. 3b).

The chi square value, computed for each transect, exceeded the critical value (alpha value < 0.001, Table 2), indicating that the summed divergence between observed and expected (occurring equally on all soils) frequencies of trees was significant. The Cramer's V index, varying from 0 to 1, was highest along transect **C** (0.21) and lowest along transect **B** (0.16) (Table 2). The significant chi square values indicate additionally that the computed Cramer's V values are statistically accurate (Norcliffe 1977). The asymmetric lambda index calculated for each transect, varying from 0 to 1, equaled approximately zero (Table 2), indicating that when all trees are considered there was no decrease in the probability for error in predicting a tree species if a soil texture is known.

TABLE 2. Tree species categories-soil texture class relationships, the statistical results.

Transects	Chi square	df(r-1)(c-1)	Cramer's V	Asymmetric lambda
A	185.73	24	0.21	0
B	122.30	24	0.16	0.007
C	231.79	20	0.22	0.03

Critical chi square is approximately 53 at alpha < 0.001

Analysis of the Soil Texture Gradient

Scattergrams depicted a sharp increase in soil texture 5 at 67.2 kilometers (south-north) along transects **B** and **C** and much less distinct increase along transect **A**. The data set was divided for analyses into a south and north sample at that location along each transect.

The slight increase in the mean frequency of soil texture 5 (at 0.4 kilometer intervals) north of 67.2 kilometers along transect **A** was not significant (alpha = 0.05), and, furthermore, the overall occurrence of this soil texture was low along the transect (Table 3). Along transects **B** and **C**, however, soil texture 5 was more frequent, and the negative t-values indicate that in both transects the north mean frequency was significantly greater than that in the south (Table 3).

Among texture 4 soils, no sharp increase was recognizable along either transect **B** or **C**. On transect **A**, however, we observed a sharp break in the distribution, with values increasing north of 76.8 kilometers. Because needleleaf trees were most frequently recorded on these soils along transect **A** (Medley 1985) we examined this break statistically and found that the mean frequency of soil texture 4 south of 76.8 kilometers was significantly less than north (alpha value < 0.001).

The linear equation determined for transect **A** had a low R^2 value (0.12), indicating that very little of the variance in the occurrence of soil texture 5 was explained by the equation. Transects **B** and **C** had higher R^2 values (0.44 and 0.57 respectively) and the y-intercepts, as well as the slope coefficients, were significant. Along the two transects the south (and north) gradients were significantly different from zero and the linear trend to the south was significantly different from the trend to the north. Graphs depicting the south to north trends reveal a similarity between transects **B** and **C** south of the break but distinct differences to the north (Fig. 4).

DISCUSSION

Forest Composition and Soil Texture Relationships

The statistical analyses reveal a significant association between the presence of certain tree species, or species categories, and soil texture. However, the

TABLE 3. The Student's t-test results.

TRANSECT DIVISION	MEAN	F—TEST Value	F—TEST Sig.	T—TEST Value	T—TEST Sig.
TRANSECT A (texture 5)					
South T9N-T15N	1.05	1.07	.722	-1.89	.060
North T16N-T18N	1.46			*(pooled)*	
TRANSECT B (texture 5)					
South T7N-T13N	.98	2.59	.000	-9.80	< .001
North T14N-T16N	3.74			*(separate)*	
TRANSECT C (texture 5)					
South T5N-T11N	2.84	2.17	.000	-9.96	< .001
North T12N-T14N	7.08			*(separate)*	
TRANSECT A (texture 4)					
South T9N-T16N	1.307	2.54	.000	-8.84	< .001
North T17N-T18N	4.604			*(separate)*	

species as beech and oak that were not site specific, and the high probability for error in predicting a tree species may be attributed to the predominance of beech on all soil textures, i.e., in nearly every case for the three transects beech would be the predicted tree species when the soil texture class is known. More importantly, the results indicate that the high frequencies of pine on coarse-textured soils are statistically significant and suggest that the relative frequency of needleleaf tree species across central Lower Michigan is related at least in part to the distribution of coarse-textured soils. These results provide quantitative support to a substantial body of previous research that has already shown a relationship between the occurrence of pines and coarse-textured soils in the Great Lakes area (Wilde 1933; Braun 1950, Livingston 1905).

The Northward Gradient in Coarse-textured Soils

We had originally hypothesized that the extent of upland coarse-textured soils increases significantly northward across the tension zone. Based on the t-test results, we accept this hypothesis, at least regarding soil texture 5 along
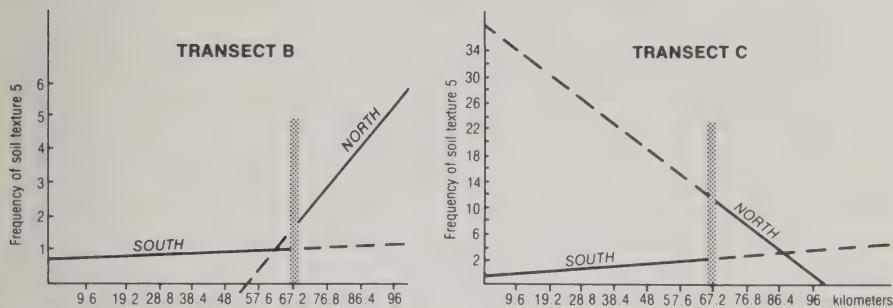
$$Y = a + b_1 X + b_2(D_1) + b_3(D_2)X$$

where $D = 1$ if north and $D = 0$ if south

EQUATIONS

$Y = .55 + .01(X) + -6.61(D_1) + .11(D_2)X$ $Y = 1.95 + .026(X) + 30.8(D_1) + -.34(D_2)X$

$\quad$ (.243)$\quad$(.006)$\qquad$(1.85)$\qquad$(.023) S.E.$\qquad$(.332)$\quad$(.009)$\qquad$(2.51)$\qquad$(.032) S.E.

$R^2 = .44$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad$$R^2 = .57$

NORTH

$Y = .55 + .01(X) + -6.61(1) + .11(1)X$ $Y = 1.95 + .026(X) + 30.8(1) + -.34(1)X$

$Y = -6.05 + .12(X)$$\qquad\qquad\qquad\qquad\qquad$$Y = 32.75 + -.314X$

SOUTH

$Y = .55 + .01(X) + -6.61(0) + .11(0)X$ $Y = 1.95 + .026(X) + 30.8(0) + -.34(0)X$

$Y = .55 + .01(X)$$\qquad\qquad\qquad\qquad\qquad\quad$$Y = 1.95 + .026(X)$

Fig.4. Graphic representations of the linear equations. Dashed lines represent the projected trends for the south and north samples.

transects **B** and **C** and texture 4 along transect **A**. The null hypothesis, that there is no significant increase, could not be rejected, however, in the analysis of soil texture 5 along transect **A**.

The distribution of soil texture 5 and the degree of its association to forest composition were not uniform across the three transects. In contrast to transects **B** and **C**, along transect **A** this soil group was infrequently observed and it failed to show a sharp increase northward or a definable northward trend. Moreover, pines were not particularly frequent on it but occurred most frequently on soil texture 4. Evidently, the distribution of texture 5 along transect **A** was localized and exhibited contrasting characteristics, such as poor soil drainage or a high water table, which were not examined in this study and complicated general relationships between soil texture and tree species distribution. Furthermore, regression analyses depict distinct differences in the northward trend in soil texture 5 along transect **B** and **C**, most probably related to differences in the

deposition of glacial deposits across central Lower Michigan (Medley 1985; Ferrand & Bell 1982).

The close association between needleleaf tree species and coarse-textured soils and the increase northward in the occurrence of these soils suggest that the regional soils pattern helps to define the vegetation tension zone. Is this statistical relationship between needleleaf trees and coarse-textured soils coincidence while the real northward control of the phytogeography is climate? Of course, the ultimate control of the transition toward a mixed-coniferous forest, as characterized by the northern limits of southern broadleaf species and also by the southern limits of northern needleleaf species, is climatic. Sandy sites similar to texture 4 and 5 soils located south of the study area in northern Indiana support only broadleaf deciduous species, whereas similar sites in northern Michigan and Ontario are dominated by needleleaf species (Lindsey 1961; Wilde 1933). However, our results address the distribution of tree species within this northward climatic transition, and it seems that across this region the sharpness as well as other characteristics of the northward trend toward needleleaf forest are at least partially explained by the distribution of coarse-textured soils. By this view, the present location of the tension zone, as defined by an abrupt increase in needleleaf trees, is a lingering reflection of late-glacial depositional processes rather than a result of local climatic gradients.

SUMMARY

The objective of this study was to identify, through statistical analyses, possible relationships between presettlement forest composition and the texture of the upper soil profile across the vegetation tension zone of central Lower Michigan. Based on earlier studies we suspected that needleleaf species are site specific to coarse-textured soils, which increase abruptly northward across this region. We hypothesized that the measured association between tree species and soil textures is statistically significant and, secondly, that the occurrence of coarse-textured soils increases significantly across the tension zone.

Data were recorded on the presettlement forest composition, its relationship to specific soil texture classes, and the distribution of soil texture classes along three belt transects which extend south to north across central Lower Michigan. The results from several statistical analyses demonstrate that the distributions of tree species and soil texture are significantly related. Neddleleaf trees are most frequent on coarse-textured soils, and sugar maple on fine-textured soils, but the nearly equal distribution of most deciduous species, and the predominance of beech, on all soil textures lessen the association strength and tree species predictability if the soil texture is known. Coarse-textured soils increase significantly north across the tension zone but there are east-west variations in the trend. We conclude that the occurrence of needleleaf trees is closely related to coarse-textured soils within this vegetation transition and that the regional soils pattern helps define the sharpness of the tension zone.

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On the cover: Triphora trianthophora, *three birds, photographed in Leelanau Co. Michigan
by John Van Arsdale.*

THE

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MICHIGAN BOTANIST

May, 1987

Flora of Isle Royale

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THE VASCULAR FLORA OF ISLE ROYALE NATIONAL PARK

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Over the past 25 years, many new plants have been discovered on Isle Royale by the authors, other researchers, and National Park Service employees. More recently a 5 year research project funded by the National Park Service gathered data on the relative abundance and habitat preference of Isle Royale vascular plants. This article represents the culmination of those efforts.

The text reviews botanical exploration on Isle Royale and discusses major plant communities. The accompanying annotated catalogue contains all of the vascular plants found on Isle Royale, each of which is supported by one or more verified herbarium specimens. More than one hundred and fifty-three new species have been added since Clair Brown published his catalogue of the flora of Isle Royale in 1937. Certainly there are new species of plants yet to be found. Notification, with documentation, of the discovery of new species will be appreciated and will facilitate revisions of the catalogue.

PHYSICAL ENVIRONMENT

Isle Royale National Park is situated in the northwest corner of Lake Superior at approximately 89° west longitude, 48° north latitude. The park is an archipelago of islands, the largest being 72 km long in a northeast to southwest direction and 14 km wide at its widest point. There are about 200 smaller islands surrounding the main one, ranging in size from emerging rocks to Amygdaloid Island, which is 6.4 km long. Inland, there are 83 lakes. About 24 km to the northwest is the Ontario shoreline of Lake Superior, and 72 km to the southeast lies the Keweenaw Peninsula of Michigan.

The geology of the Island is comprised of a series of ridges and valleys which parallel the long axis of the island. The Greenstone Ridge is the longest, extending from one end to the other, and also reaching the highest elevation near the southwest end (425 meters above sea level, 241 meters above Lake Superior).

Isle Royale is composed of rocks of the Keweenaw Age of the late Precambrian. Sandstones and conglomerates are imbedded in successive lava

flows which went through elevation, tilting, faulting, and erosion to result in the ridges. The last glacial stage to cover the island, the Wisconsinan during the late Pleistocene, receded from Isle Royale only 10,000 years ago. Glacial erosion on Isle Royale has resulted in thin, poorly developed soils, an important factor in plant distribution.

There is little climatological data for Isle Royale. Cool weather is characteristic of the spring and fall. Summer rainfall leaves no month with a mean less than 5.08 cm. Mean temperature for May through October is 11.6°C (Strommen, 1969). Late springs, cool summers, and early frosts in fall have a marked effect on the growing season.

BOTANICAL HISTORY

Isle Royale has long been favored for botanical and ecological research. Botanical exploration dates back to 1840, when Douglass Houghton briefly visited Isle Royale and recorded notes on the vegetation in his journal (Brown, 1937). Subsequently, many other geologists visited the island. William Ives, in 1847, took field notes on the vegetation when he conducted a rectangular survey of the island (Brown, 1937). Also in 1847, George J. Dickenson and James McIntyre briefly described the vegetation in a geological report to the U. S. Senate. Dickenson wrote of encountering "hackmatack and thick undergrowth," cedar swamps, spruce, and fir (Jackson, 1849).

One year later, J. W. Foster and J. D. Whitney visited Isle Royale. In their report on the copper district of the Lake Superior region, Foster and Whitney describe the "desolate appearance" of Isle Royale, as "a dwarfed growth of cedars and birches hung with drooping moss" (Foster and Whitney, 1850). It was probably not a moss that they saw, but rather the lichen *Usnea,* commonly called "old man's beard." In a later report on the iron region, Whitney devoted an entire chapter to botany which listed plants from the region, including 15 from Isle Royale (Foster and Whitney, 1851).

T. C. Porter collected in the Lake Superior region in 1865, but the results of his work, including 22 species from Isle Royale, were not published until 1921 by W. L. McAtee.

These first descriptions of the vegetation of Isle Royale did little to characterize the nature of the flora. Later visits, however, especially that of A. E. Foote, were the beginning of extensive plant collecting in a diversity of habitats. Foote led a group from the University of Michigan and several hundred specimens from their collections are deposited in the herbarium there. Four specimens collected by the "University Party, Isle Royale" as the herbarium labels read, have not been found on Isle Royale since Foote's expedition. These are: *Dicentra cucullaria* (Dutchman's breeches), *Sanguinaria canadensis* (bloodroot), *Erythronium americanum* (trout lily) and *Impatiens pallida* (pale touch-me-not). All have been positively identified from herbarium specimens. It

is unlikely, given the extent of subsequent collecting on Isle Royale and the large area over which a plant like *Erythronium americanum* could flourish, that these four plants from Foot's collection were actually collected on Isle Royale. It is known that Foote's party stopped in Ontonagon, Michigan on the same expedition, so it is possible that the specimens were collected there and mislabeled as Isle Royale specimens. Nevertheless, they are included here as plants that, if found on Isle Royale in 1868, are probably now extinct on the island.

C. E. Allen and C. S. Stuntz made large collections on the island in 1901. Although not published at the time, Clair Brown later examined lists provided by Dr. Allen and included the records of Allen and Stuntz in his 1935 report. However, many of the plants they recorded have been excluded due to misidentification.

During the summer of 1904, the first ecological study of plant communities on Isle Royale was made as part of a study on the ecology of northern Michigan by an expedition from the University of Michigan. Dr. A. G. Ruthven directed a study on the southwestern end of the island. He set up 10 field stations in which he studied ecological "facts and relations." Ruthven's study is beneficial because it included all of the representative habitats, including aquatic ones, and was the first to look at plant processes, i.e., the dynamics of plant succession. This way of studying plant communities by analyzing plant relationships in terms of change was considered innovative at the time. Ruthven was also the first to note the boreal nature of the plant communities and noted 91 plant species in his annotated list (Adams, 1906). It is unfortunate that herbarium specimens were not preserved, for some species reported by Ruthven have not since been found.

In 1905 another party from the University of Michigan made a thorough survey of the ecology of Isle Royale. W. P. Holt, under the direction of C. C. Adams, set out to make "a general reconnaissance of the plant life on as many different parts of the island as possible." The resulting work, published in a classical study of Isle Royale ecology, discussed plant societies and contained an annotated list that included 283 vascular plants along with locations and habitats (Adams, 1909).

In 1909 and 1910, W. S. Cooper studied the vegetation ecology of Isle Royale. Five papers were published as a result of his work (Cooper, 1911, 1912, 1913a, 1913b, 1914). His catalogue of the flora, the most complete to that date, listed over 500 species and their habitats. Cooper delineated five courses of succession and accurately assigned each plant he reported to one of them. His catalogue also contained records of other collectors, most notably those collected by Holt in 1905. With Isle Royale becoming more popular as an ecological study site, the need for a concise list of the flora became evident.

In 1930, with funding from the State of Michigan for a survey of Isle Royale, the University of Michigan Herbarium sent a party to the island to

conduct a botanical study. Clair A. Brown compiled a list of the ferns and flowering plants found on Isle Royale. His list of 671 species and varieties was based on his own collections and the records of others (Brown, 1937). For many years Brown's work was the conclusive work on Isle Royale flora; indeed, it was the only complete source available and consequently was cited in nearly every ecological paper that followed it. As thorough as Brown was in citing the works of others, he was negligent in checking identification of herbarium specimens and cited many species based on written records alone.

The value of Brown's work lies in the descriptive record it provides of the vegetation 54 years ago. Since that time, no one has published extensive collection records for Isle Royale. Collections have taken place though, and fortunately specimens have been deposited in various herbaria. Others who have contributed significantly to the knowledge of Isle Royale flora through herbarium specimens (since 1930) are Clifford M. Wetmore, Harold and Virginia Bailey, Philip C. Shelton, and Edward G. Voss. Also, collections by C. S. Stuntz and C. E. Allen date from 1901.

More than 50 years have passed since Clair Brown compiled his catalogue of the flora of Isle Royale. Since that time, many new species have been found, the nomenclature has changed and many of Brown's specimens and those of other collectors have been found to be misidentified. An up-to-date reference for researchers and park personnel was long overdue.

As part of a National Park Service-funded five year research project entitled "Flora and Vegetation Ecology of Isle Royale National Park," this work provides an up-to-date reference for the flora of Isle Royale. It represents a compilation of more than a century of data. By examining herbarium specimens and searching the literature for authentic published records, the most accurate and up-to-date list of the flora of Isle Royale has been completed, including many new species discovered in our own systematic sampling.

PLANT COMMUNITIES

Isle Royale is densely forested. Two distinct upland forest types reach their climax there. The island is situated at the southernmost limit of the northeastern conifer region. The boreal forest type (*Abies basamea/Betula papyrifera/Picea glauca*) achieves its climax at the lower elevations around the periphery of the island where climatic conditions are moister and cooler (Linn, 1955). All other plant societies in peripheral areas lead to this permanent vegetational stage. Other tree species commonly encountered in the boreal forest are *Thuja occidentalis* and *Populus tremuloides*. Common ground cover plants found in the mature northern boreal forest are *Aster macrophyllus, Aralia nudicaulis, Cornus canadensis, Clintonia borealis, Linnaea borealis*, and *Lycopodium annotinum*. Tall shrubs are represented by *Rubus parviflorus* and *Alnus crispa*.

The second climax association is found on the western-most end of the island. At higher elevations away from Lake Superior, where the soil is drier and the air warmer, the sugar maple and yellow birch association (*Acer saccharum* and *Betula alleghaniensis*) is the climax forest type (Linn, 1955). Sugar maple is at its northernmost limit here as part of the temperate deciduous forest biome. This smaller climax association covers only about 7% of the island. Other tree species occasionally found in this forest are *Sorbus decora* and *Acer spicatum*. Ground cover is sparse and is dominated by young maples. Other ground cover species are *Lycopodium lucidulum*, *Steptopus roseus*, and *Clintonia borealis*. These two upland forest types which dominate Isle Royale are in sharp contrast to the lowlands between the parallel system of ridges. These contain a vast amount of wooded swamp composed of *Picea mariana* and *Thuja occidentalis*.

Also in these lowland areas many bogs are found. The bog communities of Isle Royale are rich in plant life, with sedges often dominating the sphagnum mat. Common bog sedges are *Carex livida, Carex limosa, Rhynchospora alba* and *Eriophorum spissum*. Other common bog species are *Ledum groenlandicum, Sarracenia purpurea, Vaccinium oxycoccos, Menyanthes trifoliata, Drosera* spp., and *Chamaedaphne calyculata*.

In 1936 20% of the island was burned and the humus layer was destroyed. This region, stretching from Siskiwit Bay in the west to Moskey Basin in the east, is now almost a pure stand of paper birch with scattered quaking aspen. The abundant ground cover species here are *Aster macrophyllus, Rubus parviflorus, Pteridium aquilinum*, and *Aralia nudicaulis*.

There have been two other recently burned areas on Isle Royale. Four hectares burned at Card Point in 1976 and less than one hectare burned at McGinty's Cove in 1975. Both of these areas are on the westernmost end of the island and are thick with ground cover vegetation. *Rubus parviflorus, Rubus strigosus, Epilobium angustifolium*, and *Calamagrostis canadensis* are the dominant post-fire species at Card Point, while *Rubus strigosus, Aralia nudicaulis, Milium effusum*, and *Sambucus pubens* are dominant at the McGinty Cove burn site (Janke, 1981).

Fire has played an important role in the boreal forest on Isle Royale. Fire drastically postponed the reproduction of balsam fir in the 1936 burn area. Without a nearby seed source balsam fir reproduction is minimal. Paper birch, on the other hand, can reproduce well on a mineral soil, hence it can act as a post-fire pioneer (Janke, 1978).

Another impact on the boreal forest is that of moose. Severe browsing by moose has nearly eliminated *Taxus canadensis* on the main island, but it remains as one of the dominant ground cover species on many of the outer islands. Likewise, *Sorbus decora* is sparsely distributed in those areas that are easily accessible to moose. Snyder and Janke (1976), when measuring the long term effects of moose browsing, found a significant decrease in balsam fir

density and an increase in white spruce density. White spruce is not eaten by moose.

A phytosociological community of notable interest is the arctic-alpine community associated with the rocky shoreline of Lake Superior. The favorable glacial climate of the Pleistocene allowed artic-alpine plants to migrate into the area; now they persist on the shoreline because they are exposed to cool winds and moist atmosphere from Lake Superior (Given and Soper, 1981). Butters and Abbe (1953) call these species "relics of the late Wisconsin dispersal," that is, plants that were well established before the boreal forest. It is implausible to suggest the migration of so many species of arctic affinity in more recent times; this community of plants, therefore, is indicative of a drastic post-glacial change of climatic conditions in the vicinity of Isle Royale. Shoreline plants of arctic-alpine affinity, as defined by Given and Soper (1981), and found on Isle Royale are listed in Table I.

Table I. Plants of arctic-alpine affinity found on Isle Royale (Based on Given and Soper, 1981).

Species	Family
Lycopodium selago	Lycopodiaceae
Selaginella selaginoides	Selaginellaceae
Dryopteris fragrans	Polypodiaceae
Poa alpina	Gramineae
Poa glauca	Gramineae
Trisetum spicatum	Gramineae
Carex capillaris	Cyperaceae
Scirpus cespitosus	Cyperaceae
Tofieldia pusilla	Liliaceae
Polygonum viviparum	Polygonaceae
Sagina nodosa	Caryophyllaceae
Draba incana	Cruciferae
Saxifraga paniculata	Saxifragaceae
Saxifraga tricuspidata	Saxifragaceae
Empetrum nigrum	Empetraceae
Vaccinium uliginosum	Ericaceae
Vaccinium vitis-idaea	Ericaceae
Castilleja septentrionalis	Scrophulariaceae
Euphrasia hudsoniana	Scrophulariaceae
Primula mistassinica	Primulaceae
Pinguicula vulgaris	Lentibulariaceae

Aside from the rock shore plants of arctic affinity, other common rock shore species are *Deschampsia cespitosa, Campanula rotundifolia, Achillea*

millifolium, and *Potentilla fruticosa.* At higher elevations above the rock shore, *Juniperus horizontalis* and *Arctostaphylos uva-ursi* are more frequently encountered. Their role in primary rock shore succession is evident—they help collect soil among their roots and creeping stems, allowing other species to become established.

There are several plants found on Isle Royale (and often in adjacent areas of the Great Lakes region), that have their major distribution in the west, and occur elsewhere no closer to Isle Royale than the Black Hills of South Dakota. These western disjunct species have long been a puzzle for botanists and their origin a source of controversy. Fernald (1925, 1935) attributed the persistence of these plants to their survival (during periglacial times) on high bluffs which were not covered by the Wisconsinan glacier. He hypothesized that the plants subsequently spread to their present distribution, some being more readily dispersed than others. This idea is generally rejected now due to the absence of geological evidence.

Reevaluation of Fernald's hypothesis by many phytogeographers has led to a more feasible explanation for the occurrence of these disjunct species. Marquis and Voss (1981), in a well researched paper, discuss the criteria for disjunction and the alternatives to Fernald's hypothesis. They conclude with two explanations for the distribution of western species in the Great Lakes region. The first claims a preglacial western distribution for the disjuncts. As the glacier retreated, the plants migrated eastward along the glacial front and established themselves in niches free from competition. The range of these disjuncts was interrupted by a postglacial dry period and by competition from invading species. Hence, cool, moist microclimates such as those found on Isle Royale and in the Black Hills are the only areas where these often montane western species could persist. The other explanation holds that there was a transcontinental distribution of the species that survived only at the edges of the glacial front in Wisconsin. As the glacier retreated, the plants reinvaded the region and survived only in favorable microclimates. Whatever explanation one chooses to accept, it is probable that a more widespread distribution of these species existed at one time.

Table II lists the western disjunct species found on Isle Royale. Based on Marquis and Voss (1981), this list contains only those species which clearly have a discontinuous distribution on Isle Royale. Since most of the disjuncts are of Cordilleran habitats in the west, it is not surprising to find that most of them thrive in the rocky areas of Isle Royale. Most visible of all the disjuncts is *Rubus parviflorus.* It is widely distributed throughout the island in wooded and open areas. In the west it ranges from Alaska to Mexico, with another disjunction in the Black Hills.

Most notable among the disjuncts is *Oplopanax horridus,* commonly called devil's club. Its distribution on Isle Royale is small; it is restricted to a few shaded rocky or swampy habitats on the northeast end of the main island,

and on several of the outer islands. Its major distribution in western North America ranges from southern Alaska to Oregon and northwestern Montana. W. A. Wheeler first reported it in 1901 in a list of the most notable species he had collected on Isle Royale in 1900. He called the occurrence of devil's club "remarkable" and reported collecting it on "Passage Island" and "Black's Point" (probably Blake's Point, where it is now found). *Oplopanax* is also found on nearby Porphyry Island and the Slate Islands of Ontario.

Table II. Western disjunct species found on Isle Royale (based on Marquis and Voss, 1981).

Species	Family
Cryptogramma crispa	Polypodiaceae
Festuca occidentalis	Gramineae
Poa canbyi	Gramineae
Goodyera oblongifolia	Orchidaceae
Polygonum douglasii	Polygonaceae
Arenaria macrophylla	Caryophyllaceae
Arabis holboellii	Cruciferae
Crataegus douglasii	Rosaceae
Rubus parviflorus	Rosaceae
Oplopanax horridus	Araliaceae
Osmorhiza chilensis	Umbelliferae
Collinsia parviflora	Scrophulariaceae

In February of 1983 the Michigan Legislature approved a revised list of threatened and endangered plants for the state. Thirty-nine of these are found, some exclusively, on Isle Royale. *Orchis rotundifolia* is the only plant of endangered status found on Isle Royale. It has been collected twice on the island—once in 1942 two miles northwest of Lake Desor, and again in 1981 in a cedar swamp northwest of Conglomerate Bay.

The Michigan Natural Features Inventory, a division of the Michigan Department of Natural Resources, has designated another category of plants called "special concern" plants. These plants, while not legally protected in the state, face the possibility of being given the status of threatened if action is not taken now to preserve them in their natural habitats. There are 16 plants of special concern status found on Isle Royale.

It is interesting to note, given that Isle Royale has so many plants with unusual distributions, that there are no nationally protected plants within the boundaries of the park. *Listera auriculata*, a small orchid of the boreal forest, has a rating of C2 on the Department of the Interior Endangered and Threatened Wildlife and Plant list. This means that there is insufficient information to

justify legal protection, but the plant is under consideration for placement on the federal list.

THE VASCULAR FLORA

The following list of approximately 700 species contains every known vascular plant found on Isle Royale either currently or in the past, naturally occurring or introduced. Each plant in the catalogue is supported by at least one herbarium specimen. For the monocots, the records of Dr. Edward G. Voss (University of Michigan Herbarium, Ann Arbor) were used to verify existing specimens. Specimens used for verification are in herbaria at the following locations:

> University of Michigan Herbarium, Ann Arbor, Mich.
> Isle Royale National Park Herbarium, Houghton, Mich.
> University of Minnesota, Minneapolis, Minn.
> Gray Herbarium, Harvard University, Cambridge, Mass.
> University of Notre Dame, Notre Dame, Indiana
> Ohio State University, Columbus, Ohio
> New York Botanical Garden, Bronx, New York
> University of Wisconsin, Madison, Wisc.
> Michigan State University, East Lansing, Mich.

The examination of herbarium specimens that date back to the 19th century creates a problem in that some plants collected long ago have not been relocated. Should they be included with a current inventory of the flora? A fitting example of this dilemma is *Vaccinium vitis-idaea*, the mountain cranberry. It was collected by A. E. Foote in 1868 from Smithwick Island, a narrow, rocky island south of the northeastern tip of the main island. This subarctic species, if not extinct on Isle Royale, must have a very local population. It is found on Ontario shores of Lake Superior, so it is feasible that it could occur on Isle Royale in a similar habitat. It is included in this catalogue as a plant presumed to be extirpated from Isle Royale

Seventy-four species reported from the island by Brown have been excluded from this catalogue. Either there are no known herbarium specimens to verify existence of these plants in the park, or a misidentification of the herbarium specimen has been discovered.

In this report, nomenclature for the Pteridophytes follows *A Field Manual of the Ferns and Fern Allies of the United States and Canada* (Lellinger, 1985). For the Gymnosperms and Monocots, nomenclature follows *Michigan Flora Part I* (Voss, 1972). Dicot families through the Cornaceae follow *Michigan Flora Part II* (Voss, 1985). The Violaceae follow the nomenclature of H. Ballard, Jr., Western Michigan University. The 23 families remaining again follow *Gray's manual*. Varieties and forms of species have not been included in this catalogue.

For each plant, a short description of habitat preference and abundance within the park is given, along with the common name. Abundance was determined from statistical data collected during ecological studies conducted by R. A. Janke. When a plant was not encountered in sampling, abundance and habitat preference was based on information taken from herbarium labels. Plants that are threatened, endangered or of special concern in the state are indicated as such and when possible, more concise information is given as to their location. The plants are grouped by family in Gray's Manual order, but the genera are alphabetical within each family. *Species are designated "introduced" only where strong evidence suggests that human activity caused their establishment on Isle Royale.* Species preceded by asterisks denote: * A Special Concern Plant, ** A Threatened Plant, and *** An Endangered Plant.

Equisetaceae   Horsetail Family

Equisetum arvense L. [field horsetail]. Frequent, damp woods, and stream banks.

Equisetum fluviatile L. [water horsetail]. Frequent, emergent or on the shores of swamps and lakes. Forma *polystachyum* is also found--it has a strobilus at the tip of each branch.

Equisetum hyemale L. [smooth scouring rush]. Frequent, moist areas of the boreal forest.

Equisetum palustre L. [marsh horsetail]. Common, swamps and lakeshores.

Equisetum pratense Ehrh. Rare, moist woods and meadows.

Equisetum scirpoides Michx. Uncommon, moist woods and stream banks.

Equisetum sylvaticum L. [wood horsetail]. Frequent, wet woods and swamps.

Equisetum variegatum Schleich. [variegated scouring rush]. Uncommon, moist shores.

Lycopodiaceae   Clubmoss Family

Lycopodium annotinum L. [bristly clubmoss]. Frequent, mature boreal forest and recent burns.

Lycopodium clavatum L. [common clubmoss]. Frequent, mature boreal forest; occasional, jack pine forest.

* *Lycopodium complanatum* L. [trailing ground-pine]. Uncommon, mature boreal forest.

Lycopodium inundatum L. [bog clubmoss]. Rare, sphagnum bogs.

Lycopodium lucidulum Michx. [shining clubmoss]. Frequent, sugar maple forest, recent burns, and boreal forest on the western end of the island.

Lycopodium obscurum L. [ground-pine]. Frequent, young boreal forests, and recent burns.

* *Lycopodium selago* L. Rare, an arctic-alpine species found in small "mini-bogs" of sphagnum along the rock shore.

Lycopodium tristachyum Pursh. Rare, dry open areas.

Selaginellaceae   **Spikemoss Family**

Selaginella ruprestris (L.) Spring. Uncommon, rock shore of Lake Superior and dry rocky openings inland.

Selaginella selaginoides (L.) Link [northern spikemoss]. Rare, moist depressions and pools of rock shore. An arctic-alpine species.

Isoetaceae   **Quillwort Family**

Isoetes macrospora Dur. [quillwort]. Frequent, submersed in shallow water of inland lakes.

Isoetes muricata Dur. [quillwort]. Frequent, submersed in shallow water of inland lakes.

Ophioglossaceae   **Adder's tongue Family**

Botrychium lanceolatum (Gmel.) Angstr. Rare, collected only by Clair Brown from "sod ground along shore," Rock Harbor.

Botrychium lunaria (L.) Sw. [moonwort]. Rare, rocky openings. First reported in 1873 by Henry Gillman.

Botrychium matricariaefolium A. Br. Rare, moist woods.

Botrychium multifidum (Gmel.) Rupr. [leathery grape fern]. Rare, dry rocky openings.

Botrychium simplex E. Hitchc. Rare, collected only from South Government Island.

Botrychium virginianum (L.) Sw. [rattlesnake fern]. Frequent, forests.

Osmundaceae   **Flowering fern Family**

Osmunda cinnamomea L. [cinnamon fern]. Uncommon, swales and other moist, shady habitats.

Osmunda claytoniana L. [interrupted fern]. Frequent, moist woods and low ground.

Osmunda regalis L. [royal fern]. Uncommon, swamps and wet stream banks.

Sinopteridaceae   **Maiden-hair Family**

** *Cryptogramma acrostichoides* R. Brown [American rock brake]. Uncommon, dry, rocky openings inland and rock shore crevices along the south shore of the main island and Mott and Amygdaloid islands.

* *Cryptogramma stelleri* (Gmel.) Prantl. [slender rock brake]. Rare, conglomerate rock openings.

Polypodiaceae   **Polypody Family**

Polypodium virginianum L. [rock polypody]. Frequent, inland rocky openings, rock shore of Lake Superior.

Dennstaedtiaceae   **Bracken Family**

Pteridium aquilinium (L.) Kuhn [bracken fern]. Common, young forests dominated by quaking aspen or paper birch; abundant, birch forest of the 1936 burn, but scattered elsewhere.

Thelypteridaceae   **Marsh Fern Family**

Thelypteris phegopteris (L.) Slosson [narrow beech fern]. Frequent, moist shady habitats, and boreal and mixed hardwood forests.

Thelypteris palustris Schott [marsh fern]. Frequent, swamps and bogs; uncommon, swales in the boreal forest and mixed deciduous forests.

Aspleniaceae   **Spleenwort Family**

Asplenium trichomanes L. [maiden-hair spleenwort]. Rare, rock of shady cliffs.

Woodsiaceae   **Cliff Fern Family**

Athyrium felix-femina (L.) Roth [lady fern]. Frequent, boreal and mixed forests; rare, rocky openings.

Cystopteris fragilis (L.) Bernh. [brittle fern]. Uncommon, rocky island openings, rocky shoreline of Lake Superior, and forests.

Gymnocarpium dryopteris (L.) Newn. [oak fern]. Common, boreal forest and mixed deciduous forest.

Matteuccia struthionopteris (L.) Tod. [ostrich fern]. Uncommon, moist boreal forest and mixed deciduous woods.

Onoclea sensibilis L. [sensitive fern]. Uncommon, moist swales of boreal and hardwood forests.

Woodsia ilvensis (L.) R. Brown [rusty cliff fern]. Frequent, rock shore crevices; uncommon, rocky openings along ridges.

Dryopteridaceae   **Wood Fern Family**

Dryopteris carthusiana (Villars) H. P. Fuchs [toothed wood fern]. Common, moist boreal forests and swamps.

Dryopteris cristata (L.) A. Gray [crested wood fern]. Frequent, moist shady habitats and swamps; uncommon, bogs.

* *Dryopteris expansa* (presl.) Fraser-Jenkins & Jermy [spreading wood fern]. Uncommon, boreal forest.

Dryopteris fragrans (L.) Schott [fragrant wood fern]. Uncommon, shady cliffs and rock shore crevices.

Dryopteris intermedia (Muhl.) A. Gray [fancy fern]. Common, boreal and mixed hardwood forests.

Dryopteris marginalis (L.) A. Gray [marginal wood fern]. Uncommon, boreal and hardwood forests.

Taxaceae   **Yew Family**

Taxus canadensis Marsh. [American yew]. Abundant, Passage Island; and common, other outer islands. Heavy browsing by moose has resulted in sparse distribution of the plant on the main island.

Pinaceae   **Pine Family**

Abies balsamea (L.) Mill. [balsam fir]. Common, boreal forest, becoming the most dominant tree species in mature forests; frequent, swamp margins and rock shore; uncommon, jack pine stands.

Larix laricina (DuRoi) K. Kock. [tamarack]. Frequent, bog margins; occasional, swamps.

Picea glauca (Moench) A. Voss [white spruce]. Common, mature boreal forest as one of the dominant species; scattered elsewhere throughout the island.

Picea mariana (Miller) BSP. [black spruce]. Common, bogs and swamps —the most abundant wetland tree species; frequent, jack pine stands.

Pinus banksiana Lamb. [jack pine]. Uncommon, ridges and dry rocky openings in poor soil; locally abundant, Saginaw Peninsula area.

Pinus resinosa Aiton [red pine]. Uncommon, rocky openings on ridges.

Pinus strobus L. [white pine]. Frequent, throughout the park.

Cupressaceae   **Cypress Family**

Juniperus communis L. [common juniper]. Common, rock shore (and inland rocky openings) in the later stages of primary succession; common, jack pine woods.

Juniperus horizontalis Moench [creeping juniper]. Common, rock shore crevices and inland rocky openings in the later stages of primary succession.

Thuja occidentalis L. [northern white cedar]. Common, swamps and shores; scattered, mature woods; occasional, bogs.

Typhaceae   **Cat-tail Family**

Typha latifolia L. [cat-tail]. Frequent, swamps, streams, and beaver meadows.

Sparganiaceae   **Bur-reed Family**

Sparganium americanum Nutt. Rare, shallow water of outlet at Chickenbone Lake.

Sparganium angustifolium Michaux. Frequent, shallow, calm water of inland lakes, rivers and streams, and protected coves of Lake Superior.

Sparganium chlorocarpum Rydb. Frequent, shallow water of inland lakes and streams throughout the island.

Sparganium eurycarpum Engelm. Frequent, shallow water and inland lakes.

Sparganium fluctuans (Morong) Robinson. Frequent, shallow water of lakes.

Sparganium minimum (Hartman) Fries. Frequent, rooted in shallow water with floating leaves, in lakes, streams, beaver ponds, and bogs.

Potamogetonaceae   **Pondweed Family**

Potamogeton alpinus Balbis. Rare, submersed in shallow water.

Potamogeton amplifolius Tuckerman. Frequent, submersed in shallow to deep water, sometimes forming thick mats clogging inland lakes.

Potamogeton berchtoldii Fieber. Uncommon, submersed in shallow water.

Potamogeton epihydrus Raf. Frequent, submersed in shallow water.

Potamogeton filiformis Pers. Rare, collected by Brown in six feet of water at McCargoe Cove.

Potamogeton foliosus Raf. Rare, collected in Tobin Harbor.

Potamogeton gramineus L. Common, submersed in shallow water of inland lakes, rivers and streams.

Potamogeton natans L. Common, submersed and floating in shallow water of inland lakes, streams and rivers.

Potamogeton obtusifolius Mert. & Koch. Frequent, submersed in shallow water of inland lakes.

Potamogeton praelongus Wulfen. Rare, collected once in deep water of Tobin Harbor.

Potamogeton richardsonii (Benn.) Rydb. Frequent, submersed in shallow to deep water of inland lakes and protected areas of Lake Superior.

Potamogeton robbinsii Oakes. Rare, collected once from Lake Richie, in shallow water.

Potamogeton strictifolius Bennett. Rare, collected once from Wood Lake, submersed in shallow water.

Potamogeton spirillus Tuckerman. Rare, submersed in shallow water.

Potamogeton zosteriformis Fern. Uncommon, submersed in shallow water of inland lakes.

Najadaceae **Najad Family**

Najas flexilis (Willd.) Rostk and Schmidt [bushy pond-weed]. Uncommon, rooted in shallow water of inland lakes.

Juncaginaceae **Arrow-grass Family**

Scheuchzeria palustris L. [arrow grass]. Uncommon, bog mats.

Triglochin maritimum L. Uncommon, bog mats.

Alismataceae **Water-plantain Family**

Sagittaria cuneata Sheldon [wapato]. Common, emergent in littoral zone of lakes, ponds, rivers, and streams.

Sagittaria graminea Michaux. Uncommon, emergent in shallow water or on shores.

Sagittaria latifolia Willd. [arrowhead]. Common, emergent in shallow water or on mucky shores.

Hydrocharitaceae **Frog's bit Family**

Elodea canadensis Michaux [elodea]. Uncommon, submersed in shallow water of lakes, ponds, rivers, and streams.

Vallisneria americana Michaux [wild-celery]. Uncommon, submersed in lakes, ponds, rivers, and streams.

Gramineae **Grass Family**

Agropyron repens (L.) Beauv. [quack grass]. Uncommon, old disturbed sites. Probably introduced with horse feed.

Agropyron trachycaulum (Link) Malte [wheatgrass]. Frequent, old and recent burns, rocky openings, and disturbed sites; uncommon, mixed deciduous forests.

Agrostis gigantea Roth [redtop]. Uncommon, meadows, forest clearings, and rocky openings; rare, bogs.

Agrostis hyemalis (Walter) BSP. [ticklegrass]. Frequent, rock shore, beaver ponds, boreal forest clearings, rocky openings, lake shores, and old burns; uncommon, bogs.

Arrhenatherum elatius (L.) Presl. [tall oatgrass]. Uncommon, rocky soil in clearings of boreal forest and other disturbed sites.

** *Beckmannia syzigachne* (Steudel) Fern. [slough grass]. Rare, collected by Brown on a gravelly point opposite Birch Island. He assumed it to be introduced.

Bromus ciliatus L. [fringed brome grass]. Uncommon, beaver ponds, mixed deciduous forests, and swamps.

Bromus inermis Leysser [smooth brome grass]. Uncommon, lake margins, meadows, and disturbed sites.

Calamagrostis canadensis (Michaux) Beauv. [blue-joint grass]. Abundant, nearly every habitat of the park, but especially the margins of beaver ponds and swamps.

Calamagrostis inexpansa Gray. Rare, rock shore and rocky swamps.

** *Calamagrostis lacustris* (Kearney) Nash [reed grass]. Rare, collected by Brown from an open rock ridge at McCargoe Cove and a rock opening at Rock Harbor.

Cinna latifolia (Goepp.) Griseb. Frequent, old burns, mixed deciduous forests, swamps, and bogs.

Cynosurus cristatus L. [dogtail grass]. Rare, dry clearings.

Dactylis glomerata L. [orchard grass]. Uncommon,meadows and disturbed soil. Introduced.

Danthonia spicata (L.) R. & S. [oatgrass]. Frequent, rock shore, rocky openings, jack pine forests, and old burns.

Deschampsia cespitosa (L.) Beauv. [tufted hairgrass]. Common, rock shore crevices.

Deschampsia flexuosa (L.) Beauv. [common hairgrass]. Common, rocky openings, rock shore crevices, jack pine forest, old burns, and disturbed sites.

Elymus wiegandii Fern. Rare, one specimen collected from a ridge.

Festuca occidentalis Hooker [western fescue grass]. Uncommon, clearings, dry hillsides. A western disjunct species, found in the Pacific northwest to as far east as Wyoming.

Festuca saximontana Rydb. Frequent, rock shore crevices, birch-aspen and mixed forests.

Glyceria borealis (Nash) Batch. Frequent, emergent in shallow water or wet soil of beaver ponds, lakeshores, and stream banks.

Glyceria canadensis (Michaux) Trin. [rattlesnake grass]. Frequent, beaver ponds, bogs, and lakeshores.

Glyceria striata (Lam.) Hitchc. [fowl manna grass]. Frequent, beaver ponds, lake and stream shores, and swamps.

Hierochloe odorata (L.) Beauv. [vanilla grass]. Rare, collected by Brown in a moist meadow on Washington Island.

Hordeum jubatum L. [squirrel-tail grass]. Rare, collected only by Brown from Caribou Island.

Milium effusum L. [millet grass]. Frequent west of Lake Mason, beaver ponds, moist clearings, recently burned sites, and mature boreal forests.

Muhlenbergia glomerata (Willd.) Trin. [marsh wild-timothy]. Uncommon, swamps and bogs.

Muhlenbergia uniflora (Muhl.) Fern. Rare, rock shore crevices.

Oryzopsis asperifolia Michaux. Frequent, jack pine and mixed deciduous forests.

Oryzopsis pungens (Sprengel) Hitchc. Frequent, rocky openings, rock shore crevices, jack pine forests, and old burns.

Panicum depauperatum Muhl. Rare, rocky openings.

Panicum xanthophysum Gray. Rare, crevices of rocky openings.

Phalaris arundinacea L. [reed canary grass]. Uncommon, sandy lakeshore.

Phleum pratense L. [timothy]. Uncommon, meadows and disturbed sites. An introduced species.

Phragmites australis (Cav.) Steudel [reed grass]. Uncommon, shallow water of lakeshores.

** *Poa alpina* L. Rare, populations very local along the rock shoreline of North Government Island, Edwards Island, and Blake Point. An arctic species.

Poa alsodes Gray. Rare, mixed deciduous forests.

Poa annua L. [annual bluegrass]. Uncommon, rock shore of Lake Superior, rocky clearings, and lakeshores.

** *Poa canbyi* (Scribner) Piper. A western disjunct species known on the island only from Monument Rock.

Poa compressa L. [Canada bluegrass]. Frequent, rocky openings, meadows, and disturbed sites; uncommon, boreal forests.

Poa glauca Vahl. Uncommon, rock shore crevices and recent burns.

Poa nemoralis L. Uncommon, rock shore, inland rocky openings, old and recent burns.

Poa palustris L. [fowl meadow grass]. Common, beaver ponds, rock shore, rocky openings, and recent and old burns.

Poa pratensis L. [Kentucky bluegrass]. Common, rock shore, inland rocky openings, clearings in the boreal forest, and meadows.

Poa saltuensis Fern. & Wieg. Uncommon, moist open woods, recent burns.

Puccinellia fernaldii (Hitchc.) E. Voss. Rare, collected only by Brown "at outer margin of sedge mat in water, McCargoe Cove."

Schizachne purpurascens (Torrey) Swallen [false melic grass]. Uncommon, rocky clearings and dry forest sites.

* *Trisetum spicatum* (L.) Richter. Frequent, an arctic species found in rock crevices along Lake Superior.

Cyperaceae   **Sedge Family**

Carex aenea Fern. Uncommon, rock shore pools and boreal forest floor; frequent, early stages of fire succession, birch woods, and meadows.

Carex angustior Mack. Common, swamps, shallow water of lakes and beaver ponds, and moist meadows; frequent, bogs.

Carex aquatilis Wahl. Common, a circumpolar species found emergent in swamps, lakeshores, rivers, and streams.

Carex arctata Boott. Frequent, all types of forests.

Carex argyrantha Tuckerman. Frequent, swamps and beaver meadows.

** *Carex atratiformis* Britton. Uncommon, rock shore crevices and rocky beaches along Lake Superior. A boreal species.

Carex aurea Nutt. Uncommon, inland lakeshores, beaver ponds, bogs, and moist clearings.

Carex bebbii (Bailey) Fern. Frequent, swamps, beaver ponds; uncommon, rock shores and meadows.

Carex brunnescens (Pers.) Poiret. Frequent, banks of lakes and beaver ponds.

Carex buxbaumii Wahl. Uncommon, rock shore crevices and pools.

Carex canescens L. Frequent, banks and shallow water of beaver ponds; uncommon, rock shore crevices.

Carex capillaris L. Uncommon, rock shore crevices. An arctic-alpine species.

Carex castanea Wahl. Uncommon, moist soil of spruce-fir forest and swamps.

Carex cephalantha (Bailey) Bickn. Uncommon, rock shore and moist shores of inland lakes.

Carex chordorrhiza L.f. Uncommon, standing shallow water of lakes and bogs.

Carex communis Bailey. Uncommon, boreal forest.

Carex crawfordii Fern. Uncommon, moist shores of lakes and ponds.

Carex crinita Lam. Uncommon, swamps and lakeshores.

Carex cristatella Britton. Uncommon, rock shore and moist inland lakeshores.

Carex cryptolepis Mack. Frequent, swamps, shallow water of beaver ponds, and meadows; uncommon, rock shores.

Carex deflexa Hornem. Uncommon, clearings in the boreal forest.

Carex deweyana Schw. Frequent, boreal and birch-aspen woods; uncommon, early stages of fire succession.

Carex diandra Schrank. Uncommon, swamps and grass mats of lakeshores.

Carex disperma Dewey. Frequent, bog mats and swamps.

Carex eburnea Boott. Rare, rock shore crevices.

Carex exilis Dewey. Rare, bogs.

Carex flava L. Frequent, shallow water and banks of beaver ponds, swamps, and lakeshores; uncommon, rock shore.

Carex folliculata L. Rare, collected once in a bog.

Carex garberi Fern. Uncommon, margins of bogs and inland lakes and rock shores.

Carex gracillima Schw. Uncommon, lake and bog margins, moist swales in the boreal forest, and rock shores.

Carex houghtoniana Dewey. Abundant, early stages of fire succession at Card Point and McGinty's Cove; scattered, margins of lakes, swamps, and beaver ponds, and boreal forest floor. Uncommon, rocky openings.

Carex hystericina Willd. Uncommon, rock shores and shores of inland lakes.

Carex interior Bailey. Frequent, shallow water of swamps, beaver ponds, lake shores, and bogs.

Carex intumescens Rudge. Common, swamps, beaver ponds, streams, and lakes; uncommon, birch and aspen forests.

Carex lacustris Willd. Uncommon, emergent in shallow water in beaver ponds.

Carex lasiocarpa Ehrh. Common, bog mats, lakeshores, swamps, and beaver ponds.

Carex lenticularis Michaux. Uncommon, rock shore crevices and banks and shallow water of beaver ponds.

Carex leptalea Wahl. Frequent, bogs and adjacent forest; uncommon, shores of lakes and ponds.

Carex leptonervia Fern. Uncommon, birch-aspen forest.

Carex limosa L. Frequent, bogs; uncommon, shallow water of inland lakeshores.

Carex livida (Wahl.) Willd. Frequent, bog mats; uncommon, rock shores.

**   *Carex media* R.Br. Frequent, rock shore crevices along Lake Superior and grassy dry clearings. In Michigan it is found only on Isle Royale and the Keweenaw Peninsula.

Carex merritt-fernaldii Mack. Uncommon, rocky openings; rare, birch-aspen forests.

Carex michauxiana Boeckl. Frequent, swamps, shallow water and banks of beaver ponds, lake margins, bogs, and moist swales of boreal forest.

Carex oligosperma Michaux. Frequent, bogs and swamps.

Carex ormostachya Wieg. Uncommon, mixed woods.

Carex pauciflora Willd. Common, sphagnum bog mats.

Carex paupercula Michaux. Uncommon, Lake Superior rock shore pools and sphagnum bogs.

Carex peckii Howe. Rare, collected at Pickett's Bay.

Carex pedunculata Willd. Uncommon, birch-aspen woods.

Carex projecta Mack. Frequent, shallow water of beaver ponds and swamps.

Carex retrorsa Schw. Common, swamps, lakeshores, and ponds.

Carex rostrata Stokes. Common, shallow water of beaver ponds, swamps, lake margins, and bogs.

Carex rugosperma Mack. Rare, collected on the rock shore at Siskiwit Bay.

Carex stipata Willd. Abundant, swamps, meadows, and margins of lakes, streams, and beaver ponds.

Carex stricta Lam. Frequent, shallow water along the shores of lakes and ponds.

Carex tenuiflora Wahl. Uncommon, bogs.

Carex tetanica Schkuhr. Rare, known from two 19th century collections: "damp woods" and "wet places."

Carex trisperma Dewey. Uncommon, pools along the rock shore of Lake Superior, moist swales in the boreal forest, bogs, and swamps.

Carex umbellata Willd. Rare, rock shore.

Carex vaginata Tausch. Rare,collected from a bog forest near Hidden Lake and a "swampy area" near Siskiwit Bay.

Carex vesicaria L. Abundant, swamps, lakeshores, stream margins, beaver ponds, and meadows.

Carex viridula Michaux. Uncommon, marly coves, sandy shores, and stream and lake banks.

Cladium mariscoides (Muhl.) Torrey [twig-rush]. Frequent, bog mats and lake margins.

Dulichium arundinaceum (L.) Britton [three-way sedge]. Common, emergent in shallow water of lakeshores, swamps, streams, and beaver ponds.

Eleocharis acicularis (L.) R. & S. Uncommon to frequent, littoral zone of lakes, ponds, and streams.

Eleocharis elliptica Kunth. Frequent, shallow water of lakes and streams.

Eleocharis obtusa (Willd.) Schultes. Frequent, littoral zone of lakes.

Eleocharis pauciflora (lightf.) Link. Rare, collected once from a floating log at Wallace Lake.

Eleocharis smallii Britton [common spike-rush]. Common, lakeshores, swamps, and beaver ponds.

Eriophorum gracile W.D.J. Koch. Frequent, bog mats and hummocks.

Eriophorum spissum Fern. Abundant, bog mats.

Eriophorum tenellum Nutt. Uncommon, bog mats.

Eriophorum viridi-carinatum (Engelm.) Fern. Frequent, bog margins and mats.

Rhynchospora alba (L.) Vahl. Frequent, bog mats and marsh hummocks.

Rhynchospora fusca (L.) Ait.f. Uncommon but locally abundant, bogs.

Scirpus acutus Bigelow [hard stem bulrush]. Uncommon, emersed in shallow water of lakes.

Scirpus atrovirens Willd. Frequent, rock shores and swamps.

Scirpus cespitosus L. Abundant, rock shore pools and crevices, and bog hummocks. An arctic species.

Scirpus cyperinus (L.) Kunth [wool-grass]. Abundant, emersed or on wet soil in swamps, beaver ponds, bogs, streams, lake margins, and rock shore pools.

Scirpus hudsonianus (Michaux) Fern. [swaying-rush]. Uncommon, stream and lake margins and rocky shores of Lake Superior.

Scirpus microcarpus Presl. Uncommon, moist soil of stream banks.

Scirpus subterminalis Torrey. Uncommon, nearly completely submersed in the littoral zone of lakes.

Scirpus validus Vahl [soft-stem bulrush]. Uncommon, bogs.

Araceae   **Arum Family**

Arisaema triphyllum (L.) Schott [jack-in-the-pulpit]. Uncommon, sugar maple forest.

Calla palustris L. [water arum]. Frequent, rooted in mucky soil or emersed in swamps and slow moving streams.

Symplocarpus foetidus (L.) Nutt. [skunk-cabbage]. Frequent in swamps.

Lemnaceae   **Duckweed Family**

Lemna minor L. [duckweed]. Uncommon, floating on ponds, lakes, and standing water in swamps.

Lemna trisulca L. [star duckweed]. Collected only by Cooper in "aquatic delta streams."

Eriocaulaceae   **Pipewort Family**

Eriocaulon septangulare With. [pipewort]. Frequent, submersed or emersed in shallow water of inland lakes, and rooted in sand or muck.

Juncaceae   **Rush Family**

Juncus alpinus Vill. Occasional, rocky openings.

Juncus brevicaudatus (Engelm.) Fern. Common, lake and stream shores and rock shore pools; frequent, bogs.

Juncus dudleyi Wieg. Frequent, lake and stream shores and beaver ponds.

Juncus effusus L. Common, emersed in shallow water of beaver ponds and swamps.

Juncus filiformis L. Rare, collected from Gull Island.

Juncus nodosus L. Frequent, emersed in shallow water and rooted in sand.

Juncus pelocarpus Meyer. Rare, sedge mat of bog.

** *Juncus stygius* L. Rare, collected once in 1901 by C. S. Stuntz and C. E. Allen (no location given on herbarium specimen). A circumboreal species.

Juncus tenuis Willd. [path rush]. Common, along paths and disturbed soil.

Luzula acuminata Raf. [wood rush]. Occasional, moist woods.

Luzula multiflora (Retz.) Lej. [wood rush]. Uncommon, rocky, grassy openings.

** *Luzula parviflora* (Ehrh.) Desv. Uncommon, collected at Passage Island, Moskey Basin, and Washington Harbor. A circumboreal species whose only location in Michigan is Isle Royale.

Liliaceae   **Lily Family**

** *Allium schoenoprasum* L. [wild chives]. Uncommon, rock shore crevices and pools of Blake Point, Cork Island, Captain Kidd Island, and Passage Island.

Clintonia borealis (Aiton) Raf. [blue-bead lily]. Common, all forest types.

Erythronium americanum Ker [trout lily]. Collected by A. E. Foote in 1868; possibly mislabeled (see text).

Lilium philadelphicum L. [wood lily]. Frequent,clearings, rocky openings, and aspen woods.

Maianthemum canadense Desf. [wild lily-of-the-valley]. Common, woods throughout the park.

Polygonatum pubescens (Willd.) Pursh. Rare, mature maple-birch forests.

Smilacina racemosa (L.) Desf. [false spikenard]. Frequent in sugar maple forest.

Smilacina trifolia (L.) Desf. Frequent, bogs; uncommon,stream banks.

Streptopus amplexifolius (L.) DC. Frequent, wet woods and swamps.

Streptopus roseus Michaux [rose mandarin]. Frequent, mature boreal forests.

Tofieldia glutinosa (Michaux) Pers. Rare, margins of rock shore pools.

** *Tofieldia pusilla* (Michaux) Pers. Uncommon, margins of rock shore pools of Passage Island, North Government Island, and Blake Point. An arctic tundra species.

Trillium cernuum L. [nodding trillium]. Uncommon, mature forests mostly at the west end of the park; rare, wet shady sites.

Trillium grandiflorum (Michaux) Salisb. [common trillium]. Frequent, mature forests on the western end of the park.

Uvularia grandiflora Sm. [bellwort]. Rare, mature sugar maple forest at the west end of the park.

Iridaceae   **Iris Family**

Iris versicolor L. [wild blue flag]. Frequent, swamps, streams, lake margins, and beaver ponds.

Sisyrinchium angustifolium Miller. Uncommon, rock shores, rocky openings, and grassy meadows.

Sisyrinchium montanum Greene [blue-eyed-grass]. Rare, grassy clearings.

Orchidaceae   **Orchid Family**

* *Arethusa bulbosa* L. [arethusa, dragon's mouth]. Rare, bog mats.

Calopogon tuberosus (L.) BSP. [grass-pink]. Rare, collected once on a bog mat near Saginaw Point.

** *Calypso bulbosa* (L.) Oakes [calypso orchid]. Uncommon,boreal forests, often forming dense patches of up to 100 plants.

Corallorhiza maculata Raf. [spotted coral-root]. Uncommon, coniferous forests. Forma flavida is also found in which the entire plant is yellow with a white lip.

Corallorhiza striata Lindley [striped coral-root]. Uncommon, boreal forests.

Corallorhiza trifida Chat. [early coral-root]. Frequent, boreal forest clearings. A plant of special concern in Michigan.

Cypripedium acaule Aiton [moccasin flower]. Uncommon, moist forests.

* *Cypripedium arietinum* R.Br. [ram's head lady-slipper]. Rare, boreal forest clearings.

Cypripedium calceolus L. [yellow lady-slipper]. Uncommon, bogs; rare, swamps.

Cypripedium reginae Walter [showy lady-slipper]. Rare, bogs.

Goodyera oblongifolia Raf. [rattlesnake-plantain]. Uncommon, boreal forests and birch forests. A disjunct species, common in the west, but in the east,occurring only in the northern Great Lakes region and from the Gaspe Peninsula to Vermont.

Goodyera repens (L.) R.Br. [rattlesnake plantain]. Uncommon, throughout the park in moist forests.

Goodyera tesselata Lodd. Uncommon, moist forests throughout the park.

Habenaria clavellata (Michaux) Sprengel [one leafed rein orchid]. Uncommon, bogs, swamps, and moist swales in coniferous woods.

Habenaria dilatata (Pursh) Hooker [bog-candle]. Frequent, bogs.

Habenaria hookeri Gray [Hooker's orchid]. Rare, moist forest.

Habenaria hyperborea (L.) R.Br. [tall northern rein orchid]. Frequent, swamps and bogs.

Habenaria obtusata (Pursh) Richardson [blunt-leaf orchid]. Uncommon, swamps and boreal forests.

Habenaria orbiculata (Pursh) Torrey [round-leaf orchid]. Rare, mixed deciduous and boreal forests.

Habenaria psycodes (L.) Sprengel [purple fringed orchid]. Uncommon, swamps and bogs.

Habenaria viridis (L.) R.Br. [bracted orchid]. Uncommon, boreal and mixed hardwood forests.

Liparis loeselii (L.) Richard [green twayblade]. Rare, bogs and swamps.

*   *Listera auriculata* Wieg. [auricled twayblade]. Rare, boreal forest.

Listera convallarioides (Sw.) Torrey [broad-leaved twayblade]. Rare, moist swales, stream banks, boreal forests, and bogs.

Listera cordata (L.) R.Br. [heart-leaved twayblade].Uncommon, bogs and swamps.

Malaxis monophylla (L.) Sw. [white adder's tongue]. Rare, moist habitats in boreal forests.

Malaxis unifolia Michaux [green adder's tongue]. Uncommon, rocky openings, moist clearings, and swamps.

*** *Orchis rotundifolia* Pursh [round-leaved orchid]. Rare, collected two miles northwest of Lake Desor and in a cedar swamp northwest of Conglomerate Bay.

Pogonia ophioglossoides (L.) Ker [rose pogonia]. Uncommon, bogs.

Spiranthes cernua (L.) Rich. [nodding ladies tresses]. Rare, moist openings of boreal forests.

Spiranthes lacera (Raf.) Raf. [slender ladies tresses]. Uncommon, mixed forests.

Spiranthes romanzoffiana Cham. [stout ladies tresses]. Uncommon, bog

mats, rock shore pools, other wet open habitats, and dry rocky openings.

Salicaceae   **Willow Family**

Populus balsamifera L. [balsam poplar]. Scattered, rocky clearings; uncommon, pure forest stands.

Populus grandidentata Michaux [big-toothed aspen]. Uncommon, west end of the park.

Populus tremuloides Michaux [quaking aspen]. Abundant, second only to paper birch as a post fire pioneer species in the boreal forest.

Salix bebbiana Sarg. Frequent, rocky openings and rock shore crevices.

Salix discolor Muhl. Frequent, rock shore crevices and rocky clearings; uncommon, recent burn sites.

Salix humilis Marsh. Frequent, rockshore crevices and rocky openings; uncommon, boreal forest clearings.

Salix lucida Muhl. Rare, lakeshores.

Salix pedicellaris Pursh. Rare, bogs.

*   *Salix pellita* Schneider. Rare, rock shore of Greene Island.

Salix petiolaris J. E. Smith. Rare, beaver meadow along Benson Creek.

**   *Salix planifolia* Pursh. Uncommon, rocky shores.

*   *Salix pyrifolia* Andersson. Uncommon, rocky clearings and thickets.

Myricaceae   **Wax-myrtle Family**

Myrica gale L. [sweet gale]. Common, shores of lakes and ponds; uncommon, bogs and swamps; rare, rock shore pools.

Betulaceae   **Birch Family**

Alnus crispa (Aiton) Pursh [mountain alder]. Frequent, rocky clearings and boreal forest.

Alnus rugosa (DuRoi) Sprengel [speckled alder]. Common, lake and stream margins and swamps; infrequent, boreal forests.

Betula alleghaniensis Britton [yellow birch]. Abundant, sugar maple forest along the central highlandswest of Lake Desor, but generally extending somewhat   beyond the range of sugar maple in all directions.

Betula papyrifera Marsh. [paper birch]. Abundant, often in pure stands in young post-fire boreal forests,especially in the 1936 burn area, becoming less abundant as the forest matures.

Betula pumila L. Uncommon, shrub zone of bogs.

Corylus cornuta Marsh. [beaked hazelnut]. Frequent, rocky openings, especially in old unforested burns.

Ostrya virginiana (Miller) K. Koch [ironwood]. Rare, Greenstone Ridge north of Hay Bay.

Fagaceae   **Beech Family**

Quercus rubra L. [northern red oak]. Uncommon, rocky openings and maple forest.

Ulmaceae   **Elm Family**

Ulmus americana L. [American elm]. Found only at Edisen Fishery. An introduced plant.

Urticaceae   **Nettle Family**

Urtica dioica L. [stinging nettle]. Rare, disturbed soil and sandy beaches.

Santalaceae   **Sandalwood Family**

Comandra umbellata (L.) Nutt. Frequent, rocky openings and clearings in the boreal forest.

Geocaulon lividum (Richardson) Fern. [northern comandra]. Frequent, mature boreal forest, rocky clearings, rock shore of Lake Superior, and grassy clearings.

Aristolochiaceae   **Birthwort Family**

Asarum canadense L. [wild ginger]. Rare, moist, fertile soil, Windigo area.

Polygonaceae   **Buckwheat Family**

Polygonum achoreum Blake. Rare, disturbed sites.

Polygonum amphibium L. Uncommon, shores and littoral zones of lakes and streams.

Polygonum aviculare L. [knotweed]. Uncommon, rocky clearings.

Polygonum cilinode Michaux. Uncommon, rocky clearings, recent burns.

Polygonum convolvulus L. Uncommon, clearings and rocky openings. An introduced plant.

Polygonum douglasii Greene. Uncommon, rocky openings along the ridges.

Polygonum lapathifolium L. Rare, boreal forest clearings.

Polygonum sagittatum L. Rare, shores and thickets.

** *Polygonum viviparum* L. [alpine buckwheat]. Uncommon, sandy and rocky beaches and moist depressions of the rock shore. An arctic-alpine plant.

Rheum rhaponticum L. [rhubarb]. Introduced at Star, Johnson, Passage, and Captain Kidd Islands, at the Edisen and Banksund Fisheries, and at Crystal Cove.

Rumex acetosella L. [sheep sorrel]. Common, dry clearings. An introduced plant.

Rumex crispus L. [curled dock]. Rare, grassy clearings, Hat Island, Siskiwit Camp, and Pickerel Cove. Introduced.

Rumex longifolius DC. Rare, dry clearings and disturbed sites. Introduced.

Rumex triangulivalvis (Danser) Rech.f. Rare, moist shores.

Rumex obtusifolius L. [bitter dock]. Rare, clearings and disturbed sites. Introduced.

Rumex orbiculatus A. Gray [water dock]. Uncommon, lakeshores and swamps.

Chenopodiaceae   **Goosefoot Family**

Chenopodium album L. [lamb's quarters]. Rare, first collected in 1901 (no

location given) and later by Brown in 1930 near Rock Harbor fishing camp. Probably introduced.

Chenopodium capitatum (L.) Asch. [strawberry blight]. Rare, dry clearings.

Portulacaceae   **Purslane Family**

Claytonia caroliniana Michaux. Uncommon, maple woods.

Caryophyllaceae   **Pink Family**

** *Arenaria macrophylla* Hooker [big leaf sandwort]. Rare, collected by Brown in mixed woods near Siskiwit Bay east of outlet from Siskiwit Lake.

Arenaria serpyllifolia L. [thyme-leaf sandwort]. Rare, dry clearings.

Cerastium arvense L. [field cerastium]. Frequent, dry, rocky clearings.

Cerastium fontanum Baumg. [mouse-eared chickweed]. Uncommon, dry clearings.

Cerastium tomentosum L. [snow in summer]. Rare, Wright Island. Probably introduced.

Dianthus barbatus L. [sweet william]. Rare, cultivated and escaped at Windigo.

Dianthus plumarius L. [garden pink]. Rare, cultivated and escaped at Wright Island.

Lychnis chalcedonica L. [scarlet lychnis]. Rare, probably spread from cultivation.

Myosoton aquaticum (L.) Moench. Uncommon, lakeshores and swamps.

** *Sagina nodosa* (L.) Fenzl [pearlwort]. Uncommon, rock crevices.

Silene antirrhina L. [sleepy catchfly]. Uncommon, rocky openings.

Silene noctiflora L. [night-flowering catchfly]. Rare, Siskiwit Bay, Rock Harbor Lodge, and clearing near Rock Harbor Lighthouse. Introduced.

Silene pratensis (Rafn) Godron and Gren. [white campion]. Uncommon, birch forest of the 1936 burn, Mott Island near Park headquarters, Rock Harbor Lodge area, and sand beach near Siskiwit Camp. Introduced.

Silene vulgaris (Moench) Garcke [bladder-campion]. Rare, collected at Crystal Cove. Probably introduced.

Stellaria calycantha (Ledeb.) Bong. Frequent, recent burns; rare, rockshore.

Stellaria graminea L. Rare, dry clearings.

Stellaria longifolia Willd. Uncommon, dry clearings and sand banks.

Stellaria media (L.) Vill. [chickweed]. Uncommon, grassy meadows and clearings.

Ceratophyllaceae   **Hornwort Family**

Ceratophyllum echinatum A. Gray [hornwort]. Rare, collected only by Cooper in "Delta streams."

Nymphaeaceae   **Water Lily Family**

Brasenia schreberi J. F. Gmelin [water shield]. Frequent, littoral zone of shallow ponds and lakes.

Nymphaea odorata Aiton [scented water-lily]. Rare, undisturbed lakes.

**   *Nymphaea tetragona* Georgi. Rare, rooted in muck with floating leaves in
        shallow to deep water of stream deltas of Chippewa Harbor and Duncan
        Bay.

        Nuphar variegatum Durand [bullhead-lily]. Common, rooted in muck with
        floating leaves in shallow ponds, lakes, rivers, and streams.

Ranunculaceae   **Crowfoot Family**

        Aconitum napellus L. Rare, low area along footpath from Passage Island
        Lighthouse to cove boathouse. Introduced.

        Actaea pachypoda Ell. [white baneberry]. Uncommon, sugar maple forest
        and mixed hardwood forests on the western end of the park.

        Actaea rubra (Aiton) Willd. [red baneberry]. Frequent, boreal forest.

        Anemone canadensis L. Frequent, margins of streams, lakes,and swamps.

        Anemone multifida Poiret. Uncommon, rocky openings and clearings.

        Anemone quinquefolia L. [wood anemone]. Uncommon, banks of streams
        and lakes in the boreal forest.

        Anemone virginiana L. Uncommon, stream banks and lakeshores.

        Aquilegia canadensis L. [eastern columbine]. Frequent, rocky openings;
        rare, rock shore of Lake Superior.

        Caltha palustris L. [marsh marigold]. Common, streams, wet banks of
        lakes, swamps, and beaver ponds.

*   *Clematis occidentalis* (Hornem.) DC. [purple clematis]. Uncommon, dry
        clearings and open woods.

        Clematis virginiana L. [virgin's bower]. Uncommon, stream banks and
        thickets.

        Coptis trifolia (L.) Salisb. [goldthread]. Common, spruce-fir forests.

        Hepatica americana (DC.) Ker. [hepatica]. Uncommon, mixed hardwood
        forests.

        Ranunculus abortivus L. [kidney-leaf buttercup]. Common, wet banks of
        lakes, streams, beaver ponds, swamps, and mixed forests.

        Ranunculus acris L. [tall buttercup]. Frequent, meadows and clearings.

        Ranunculus fascicularis Bigelow [early buttercup]. Rare, collected from a
        ridge near Lake Linklater in 1930.

        Ranunculus hispidus Michaux [swamp buttercup]. Uncommon, lakeshores
        and swamps.

        Ranunculus longirostris Godron [white-water crowfoot]. Rare, collected
        from Lake Richie, rooted in sandy bottom.

**   *Ranunculus macounii* Britton. Rare, Brady Cove, Tobin Harbor, and low
        muddy area in forest on Passage Island.

        Ranunculus pensylvanicus L.f. [bristley crowfoot]. Uncommon, swamps,
        margins of lakes, and beaver ponds.

        Ranunculus reptans L. [creeping spearwort]. Uncommon, submersed in
        shallow water of inland lakes and coves of Lake Superior.

**   *Ranunculus rhomboideus* Goldie [prairie buttercup]. Uncommon, rocky
        openings along the ridges.

Ranunculus sceleratus L. [cursed crowfoot]. Uncommon, lake margins and swamps.

Thalictrum dasycarpum Fisch. & Ave-Lall. [purple meadowrue]. Common, beaver meadows, banks of lakes, streams, and swamps.

Papaveraceae **Poppy Family**

Sanguinaria canadensis L. [bloodroot]. Collected once by A. E. Foote, and possibly mislabled as an Isle Royale specimen (see text).

Fumariaceae **Fumitory Family**

Corydalis aurea Willd. [golden corydalis]. Rare, dry rocky openings.

Corydalis sempervirens (L.) Pers. [rock harlequin]. Frequent, rock shoreline of Lake Superior and rocky openings along the ridges.

Dicentra cucullaria (L.) Bernh. [Dutchman's breeches]. Collected once in 1868 by A. E. Foote, and possibly mislabeled as an Isle Royale specimen (see text).

Cruciferae **Mustard Family**

Arabis divaricarpa A. Nelson. Frequent, rocky openings; less frequent, rock shores of Lake Superior.

Arabis drummondii A. Gray. Frequent, rocky openings, grassy clearings, and rock shore crevices.

Arabis glabra (L.) Bernh. Rare, collected by Clair Brown.

Arabis hirsuta (L.) Scop. Uncommon, rocky openings.

Arabis holboellii Hornem. Rare, collected on the Minong Ridge in 1978. A western disjunct plant.

Arabis lyrata L. [rock cress]. Frequent, rock shore crevices and adjacent clearings.

Armoracia rusticana Gaertn., Mey. & Scherb. [horseradish]. Rare, Wright Island. Introduced.

Barbarea orthoceras Ledeb. Rare, rock shore of Lake Superior.

Barbarea vulgaris R. Br. Rare, moist meadow near Siskiwit swamp, and sandy and rocky beaches.

Berteroa incana (L.) DC. Rare, rocky clearings.

Brassica kaber (DC.) Wheeler. Uncommon, clearings and sandy shores.

** *Braya humilis* (C. A. Meyer) Robinson. Rare, collected only by P. E. Hebert "on rocks."

Capsella bursa-pastoris (L.) Medicus [shepherd's purse]. Uncommon, disturbed sites and rock shore crevices.

Cardamine parviflora L. Uncommon, rocky hillsides and ridges.

Cardamine pensylvanica Willd. Uncommon, sandy beaches, swamps, clearings, and rocky openings.

** *Draba arabisans* Michaux. Uncommon, rock shore crevices and rocky openings on Belle Isle, Passage Island, Hat Island, Captain Kidd Island, and Monument Rock.

Draba glabella Pursh. Rare, collected only on north shore of Passage Island by John Freudenstein on a rocky shore just northeast of the lighthouse.

** *Draba incana* L. Rare, collected only on the northeast end of Passage Island, the only known location in Michigan. An arctic-alpine species.

Erysimum cheiranthoides L. Uncommon, rock shore crevices.

Erysimum inconspicuum (Watson) MacM. Uncommon, rock shore crevices.

Lepidium campestre (L.) R. Br. Uncommon, rocky clearings.

Lepidium densiflorum Schrader. Uncommon, rock shore crevices.

Lepidium virginicum L. [poor man's pepper]. Uncommon, disturbed sites and clearings.

Rorippa palustris (L.) Besser [marsh cress]. Uncommon, gravelly and sandy banks.

Sisymbrium altissimum L. [hedge mustard]. Rare, collected by Brown near Rock Harbor Lighthouse in 1930 and on Little Siskiwit Island in 1931; also found in open meadow near old C.C.C. Camp, Siskiwit Bay. Introduced.

** *Subularia aquatica* L. [awlwort]. Rare, collected by Brown, submersed at Moskey Basin and not since reported.

Thlaspi arvense L. [field penny cress]. Rare, disturbed sites at Windigo. Introduced.

Sarraceniaceae   **Pitcher Plant Family**

Sarracenia purpurea L. [pitcher plant]. Common, bogs.

Droseraceae   **Sundew Family**

* *Drosera anglica* Huds. Rare, bogs and rock pool margins.

Drosera intermedia Hayne. Frequent, bogs; uncommon, lake margins and rock pool margins on Passage Island.

Drosera linearis Goldie. Frequent, bog mats; uncommon, margins of rock shore pools and lakes.

Drosera rotundifolia L. [round leaf sundew]. Common, bog mats; frequent, lake margins; occasional, margin of rock shore pools.

Crassulaceae   **Orpine Family**

Sedum acre L. [mossy stonecrop]. Rare, along the trail to the Minong Mine. Introduced.

Sempervivum tectorum L. [hen and chickens]. Rare, introduced on Star Island and Johnson Island.

Saxifragaceae   **Saxifrage Family**

Mitella nuda L. [bishop's cap]. Frequent, boreal forest and mixed hardwood forest.

* *Parnassia palustris* L. Rare, swamps and lake margins.

** *Saxifraga paniculata* Miller [yellow mountain saxifrage]. Rare, rock shore crevices along Lake Superior at McGinty Cove, Passage Island, Blake Point, Saginaw Point, Mott Island, and Heron Island. An arctic plant.

** *Saxifraga tricuspidata* Rottb. Uncommon, rock shore crevices and rocky openings.

Saxifraga virginiensis Michaux [early saxifrage]. Uncommon, rock shore crevices and inland rocky openings.

Grossulariaceae   **Gooseberry Family**

Ribes glandulosum Grauer [skunk currant]. Common, mixed woods, rocky openings, and jack pine stands.

Ribes hudsonianum Richardson. Uncommon, rocky clearings, mixed woods, and swales.

Ribes lacustre (Pers.) Poiret [bristly black currant]. Uncommon, boreal forest clearings.

* *Ribes oxyacanthoides* L. [gooseberry]. Frequent, rocky clearings and beaches.

Ribes triste Pallas [red currant]. Uncommon, rocky clearings along the ridges and boreal forests.

Rosaceae   **Rose Family**

Agrimonia striata Michaux. Uncommon but widespread, western end of the park in clearings, meadows, and sugar maple forests.

Amelanchier arborea (Michaux f.) Fern. Rare, collected once from a rocky opening along the Daisy Farm Trail in 1978.

Amelanchier bartramiana (Tausch) M. J. Roemer. Uncommon, rock shore crevices and rocky openings.

Amelanchier interior Nielsen. Frequent, rock shore crevices and inland rocky openings.

Amelanchier laevis Wieg. Uncommon, thickets and moist woods.

Amelanchier sanguinea (Pursh) DC. Frequent, rocky openings, grassy clearings, and birch-aspen woods.

Aronia prunifolia (Marsh.) Rehder. Uncommon, thickets and shores.

* *Crataegus douglasii* Lindley. Rare, rocky openings along the ridges. A western disjunct plant.

Fragaria vesca L. [woodland strawberry]. Uncommon, rocky openings and clearings in the boreal forest.

Fragaria virginiana Miller [wild strawberry]. Frequent, boreal forests, mixed hardwood forests, clearings, and rocky openings.

Geum aleppicum Jacq. Uncommon, meadows and mixed forests.

Geum rivale L. [water avens]. Rare, collected by Brown from an old burn on the slopes of Mt. Franklin.

Malus pumila Miller [apple]. Introduced at Hay Bay, Grace Island, Siskiwit Camp, Daisy Farm, Windigo, Siskiwit Mine and Greenstone Ridge just southwest of Ishpeming Point.

Physocarpus opulifolius (L.) Maxim. [ninebark]. Frequent, rock shore crevices, rocky openings, thickets, and beach margins.

Potentilla anserina L. [silverweed]. Uncommon, sandy and rocky beaches and rock shore crevices.

Potentilla argentea L. [silvery cinquefoil]. Uncommon, rocky clearings and disturbed sites.

Potentilla arguta Pursh [tall cinquefoil]. Frequent, inland rocky openings; less frequent, rock shore crevices.

Potentilla fruticosa L. [shrubby cinquefoil]. Frequent, rock shore crevices along Lake Superior.

Potentilla norvegica L. Uncommon, clearings, rocky openings, and disturbed sites.

Potentilla palustris (L.) Scop. [marsh cinquefoil]. Frequent, swamps, beaver meadows, lakeshores, and bogs.

** *Potentilla pensylvanica* L. Uncommon, rock shore crevices.

Potentilla recta L. Uncommon, clearings and disturbed sites.

Potentilla simplex Michaux [old field cinquefoil]. Frequent, clearings and rocky meadows; uncommon, rock shore crevices.

Potentilla tridentata Aiton [three-toothed cinquefoil]. Frequent, rock shore crevices, rocky openings, and clearings.

Prunus pensylvanica L.f. [pin cherry]. Frequent, grassy clearings, rocky openings, and recent burn sites.

Prunus virginiana L. [choke cherry]. Uncommon, rocky clearings.

Rosa acicularis Lindley. Common, rockshore crevices, rocky openings, and woods.

Rosa arkansana Porter. Uncommon, clearings and rocky openings.

Rosa blanda Aiton. Rare, collected by Brown from Grace Island.

Rubus parviflorus Nutt. [thimbleberry]. Abundant, young forests. A western disjunct plant.

Rubus pensilvanicus Poiret [blackberry]. Uncommon, thickets, clearings, and rocky openings.

Rubus pubescens Raf. [dwarf raspberry]. Frequent, boreal forests and grassy and rocky openings.

Rubus strigosus Michaux [red raspberry]. Abundant, recent burn sites; frequent, mixed forests.

Sorbus decora (Sarg.) Schneider [mountain-ash]. Common, woods and rock openings. In most sites, reduced to low stature by moose browsing, but attaining tree stature on moose-free offshore islands such as Passage and Smithwick.

Spiraea alba Duroi. Uncommon, moist thickets and banks.

Waldsteinia fragarioides (Michaux) Tratt. [barren-strawberry]. Uncommon, rocky openings.

Leguminosae   **Pulse Family**

Lathyrus japonicus Willd. [beach pea]. Frequent, sandy, rocky, and gravelly beaches.

Lathyrus ochroleucus Hooker. Uncommon, rocky openings, dry clearings, and jack pine stands.

Lathyrus palustris L. Uncommon, margins of swamps, streams, and lakes.

Medicago lupulina L. [black medic]. Introduced at Mott Island.

Melilotus alba Medicus [white sweet clover]. Uncommon, Siskiwit Camp and Windigo. Probably introduced via horse feed.

Melilotus officinalis (L.) Pallas [yellow sweet clover]. Uncommon, Siskiwit Camp and Windigo. Probably introduced along with preceding species.

Trifolium aureum Poll. [hop clover]. Uncommon, rocky openings, meadows, and disturbed sites. Introduced.

Trifolium hybridum L. [alsike clover]. Uncommon, clearings and disturbed sites. Introduced.

Trifolium pratense L. [red clover]. Frequent, clearings and disturbed sites. Uncommon, forests. Introduced.

Trifolium repens L. [white clover]. Frequent, clearings and disturbed sites; uncommon, forests. Introduced.

Vicia americana Willd. Uncommon, clearings, rocky openings, and mixed woods.

Vicia sepium L. Rare, collected in 1959 near the Windigo Inn.

Oxalidaceae   **Wood-sorrel Family**

Oxalis acetosella L. [common wood-sorrel]. Uncommon, mixed hardwood forests and recently burned areas.

Geraniaceae   **Geranium Family**

Geranium bicknellii Britton [Bicknell's cranebill]. Frequent, rock shoreline of Lake Superior and inland rocky openings.

Polygalaceae   **Milkwort Family**

Polygala paucifolia Willd. [gay wings]. Frequent, mature boreal forests; uncommon, jack pine stands.

Euphorbiaceae   **Spurge Family**

Euphorbia cyparissias L. [cypress spurge]. Rare, disturbed soil. Introduced.

Callitrichaceae   **Water Starwort Family**

* *Callitriche hermaphroditica* L. Rare, reported by Brown in Brady's and McCargoe's Coves.

Callitriche verna L. [water-starwort]. Frequent, in shallow water of lakes, ponds, slow-moving streams, and swamps.

Empetraceae   **Crowberry Family**

** *Empetrum nigrum* L. [black crowberry]. Rare, rock shore crevices at Scoville Point and Passage Island. An arctic species.

Anacardiaceae   **Cashew Family**

Toxicodendron radicans (L.) Kuntze [poison ivy]. Rare, collected only on the Minong Ridge near Lane Cove in recent times.

Rhus typhina L. [staghorn sumac]. Frequent, dry rocky openings along the ridges.

Aceraceae   **Maple Family**

Acer rubrum L. [red maple]. Uncommon, sugar maple forest on western end of the island; scattered, elsewhere on high ridges.

Acer saccharum Marsh. [sugar maple]. Common, high elevations on the western end of the island; uncommon, 1936 burn area. A few scattered patches occur on the eastern end of the island, especially at Mt. Ojibway.

Acer spicatum Lam. [mountain maple]. Common, forests throughout, but especially on the southwest end of the park.

Balsaminaceae   **Touch-me-not Family**

Impatiens capensis Meerb. [spotted touch-me-not]. Frequent, shores and moist banks of lakes, ponds, streams, and beaver dams. Less frequent, swamps and moist clearings.

Impatiens pallida Nutt. [pale touch-me-not]. Collected by A. E. Foote in 1868 and not since found. Possibly mislabeled (see text).

Rhamnaceae   **Buckthorn Family**

Ceanothus herbaceus Raf. Rare, found only by Janke on Stanley Ridge near Lane Cove on open rock ridge.

Rhamnus alnifolia L'Her. [alder buckthorn]. Uncommon, rocky openings and margins of bogs and swamps.

Guttiferae   **St.John's-wort Family**

Hypericum boreale (Britton) Bickn. [northern St. John's-wort]. Uncommon, sandy beaches and lakeshores.

Hypericum canadense L. Uncommon, lakeshores, bogs, and swamps.

Hypericum perforatum L. [St. John's-wort]. Rare, dry disturbed sites near the Rock Harbor Lodge. Introduced.

Triadenum fraseri (L.) Raf. [marsh St. John's-wort]. Frequent, swamps, beaver ponds, lakeshores, and banks.

Violaceae   **Violet Family**

Viola adunca J. E. Smith. Frequent, rock shore crevices and pools, inland rocky openings, and clearings.

Viola blanda Willd. Frequent, swamps and coniferous woods.

Viola conspersa Reichb. Frequent, swamps, woods, and moist banks.

Viola cucullata Aiton. Frequent, moist banks of lakes, ponds, and streams.

Viola macloskeyi F. E. Lloyd. Frequent, bog mats, and adjacent woods; uncommon, mixed woods.

Viola nephrophylla Greene. Frequent, rocky openings, and hardwood forests.

Viola pubescens Aiton [downy yellow violet]. Frequent, hardwood forests, and mixed deciduous woods.

Viola renifolia A. Gray [kidney-leaf violet]. Common, moist woods.

Viola selkirkii Goldie. Frequent, boreal forest; occasional, sugar maple forest.

Viola sororia Willd. Rare, collected only by Janke recently in rocky opening on Mt. Siskiwit.

Thymelaeaceae   **Mezereum Family**

 Dirca palustris L. [leatherwood]. Rare, collected only by A. E. Foote in 1868.

Elaeagnaceae   **Oleaster Family**

 Shepherdia canadensis (L.) Nutt. [buffalo berry]. Uncommon, dry clearings and open woods.

Onagraceae   **Evening Primrose Family**

 Circaea alpina L. [enchanter's nightshade]. Frequent, mixed hardwood forests on the western end of the island; rare, recent burns.

 Epilobium angustifolium L. [fireweed]. Abundant, recent burn sites; uncommon, dry clearings and meadows.

 Epilobium ciliatum Raf. Common, moist soil and recent burns.

 Epilobium leptophyllum Raf. Uncommon, bogs and lake margins.

* *Epilobium palustre* L. [willow herb]. Uncommon, bogs and swamps.

 Oenothera biennis L. [evening-primrose]. Rare, collected on a beach at McCargoe Cove by Clair Brown and identified by W. Dietrich, University of Dusseldorf in 1981.

 Oenothera fruticosa L. Rare, roadside at Windigo.

 Oenothera oakesiana (A. Gray) Watson and Coulter.

 Oenothera parviflora L. Uncommon, meadows and shores.

 Oenothera perennis L. Uncommon, grassy clearings and shores.

 Oenothera villosa Thumb. Rare, collected only near Washington Harbor in 1944.

Haloragidaceae   **Water Milfoil Family**

* *Myriophyllum alterniflorum* DC. Uncommon, submersed in up to two meters of water at Siskiwit Lake, Feldtmann Lake, and Sargent Lake.

 Myriophyllum exalbescens Fern. Uncommon, littoral zone of lakes and streams.

 Myriophyllum tenellum Bigelow. Frequent, submersed and rooted in the sandy bottom of lakes.

 Myriophyllum verticillatum L. Uncommon, found only by Cooper in "delta swamps."

Hippuridaceae   **Mare's-tail Family**

 Hippuris vulgaris L. [mare's-tail]. Uncommon, submersed in shallow water of lakes and ponds.

Araliaceae   **Ginseng Family**

 Aralia hispida Vent. [bristly sarsaparilla]. Uncommon, rock shores.

 Aralia nudicaulis L. [wild sarsaparilla]. Abundant, boreal forest.

 Aralia racemosa L. [spikenard]. Uncommon, forests on the western end of the island.

** *Oplopanax horridus* (J. E. Smith) Miq. [devil's club]. Uncommon, rocky or swampy habitats on Blake Point, North and South Government Islands, Boys' Island, Edwards Island, Porter Island, and Smithwick Island; very abundant, Passage Island.

Umbelliferae   Parsley Family

Carum carvi L. [caraway]. Rare, near Windigo Inn. Probably introduced.

Cicuta bulbifera L. [water-hemlock]. Frequent, swamps and margins of lakes, ponds, and streams; uncommon, bogs.

Heracleum maximum Bartram [cow parsnip]. Common, unforested areas.

Osmorhiza chilensis Hooker and Arn. [sweet cicely]. Rare,collected by Cooper from the Windigo area. A western disjunct plant.

Osmorhiza claytoni (Michaux) C. B. Clarke. Uncommon, moist woods.

Osmorhiza depauperata Phil. Frequent, mixed woods.

Pastinaca sativa L. [parsnip]. Rare, clearings at Windigo and Daisy Farm. Probably introduced.

Sanicula marilandica L. [black snakeroot]. Uncommon, woods and swamps.

Sium suave Walter [water parsnip]. Uncommon to common, shores, streams, thickets, and swamps.

Cornaceae   Dogwood Family

Cornus alternifolia L.f. [alternate-leaf dogwood]. Rare, sugar maple forest.

Cornus canadensis L. [Canada dogwood]. One of the most abundant ground cover species in the boreal forest.

Cornus rugosa Lam. [round-leaf dogwood]. Uncommon, ridge tops and disturbed sites along trails.

Cornus stolonifera Michaux [red-osier dogwood]. Common, river and stream banks, lakeshores, and swamps; uncommon, mixed forests.

Pyrolaceae   Wintergreen Family

Chimaphila umbellata (L.) Bart. [pipsissewa]. Frequent, jack pine and spruce-fir forests.

Moneses uniflora (L.) Gray [one-flowered wintergreen]. Uncommon, boreal forests.

Monotropa hypopithys L. [pinesap]. Rare, mixed forests.

Monotropa uniflora L. [Indian pipe]. Uncommon, boreal and mixed hardwood forests.

Pyrola asarifolia Michx. [pink pyrola]. Frequent, boreal and mixed forests.

Pyrola elliptica Nutt. [shinleaf]. Uncommon, boreal forest and rocky slopes.

Pyrola minor L. Uncommon, mixed woods and boreal forest.

Pyrola rotundifolia L. Rare, boreal and mixed hardwood forests.

Pyrola secunda L. [one-sided pyrola]. Frequent, boreal and mixed forests.

Pyrola virens Schweigger [green pyrola]. Uncommon, boreal and mixed forests.

Ericaceae   Heath Family

Andromeda glaucophylla Link [bog-rosemary]. Frequent, bogs and sphagnum swamps; occasional, margins of rock shore pools.

Arctostaphylos uva-ursi (L.) Spreng. [bearberry]. Common, rock shore crevices, inland rocky openings, and jack pine stands.

Chamaedaphne calyculata (L.) Moench [leatherleaf]. Abundant, bogs.

Gaultheria hispidula (L.) Bigel. [creeping snowberry]. Uncommon, bogs and adjacent forests.

Gaultheria procumbens L. [wintergreen]. Rare, recently collected in jack pine stands at Saginaw Point. Older specimens are from Hay Bay, Mt. Franklin, and Angleworm Lake.

Kalmia polifolia Wang. [bog laurel]. Frequent, bogs and sphagnum swamps.

Ledum groenlandicum Oeder [Labrador tea]. Common, bogs and sphagnum swamps.

Vaccinium angustifolium Ait. [blueberry]. Common, rocky openings and jack pine stands.

Vaccinium macrocarpon Ait. [large cranberry]. Uncommon, bogs, and hummocks around lakes.

Vaccinium myrtilloides Michx. [sour-top blueberry]. Frequent, rocky openings and jack pine stands.

Vaccinium oxycoccos L. [small cranberry]. Frequent, bogsand sphagnum hummocks in swamps.

** *Vaccinium uliginosum* L. [alpine blueberry]. Rare, rock shore crevices. An arctic tundra plant.

Vaccinium vitis-idaea L. Collected by A. E. Foote in 1868 and now believed to be extirpated from Isle Royale (see text).

Primulaceae   **Primrose Family**

Lysimachia ciliata L. Rare, collected once at Windigo in a grassy swale.

Lysimachia terrestris (L.) BSP. [loosestrife]. Common, bog hummocks, shores, moist banks, swamps, and beaver ponds.

Lysimachia thyrsiflora L. [tufted loosestrife]. Frequent, swamps, shores, and moist banks.

Primula mistassinica Michx. [birdseye primrose]. Uncommon, rock shore crevices and pool margins along Lake Superior. An arctic plant.

Trientalis borealis Raf. [starflower]. Abundant, boreal forests; occasional, jack pine stands.

Oleaceae   **Olive Family**

Fraxinus nigra Marsh. [black ash]. Uncommon, wooded swamps.

Syringa vulgaris L. [lilac]. Rare, site of old Belle Isle Lodge, Johnson Fishery at Chippewa Harbor, and old fishery at Star Island. Introduced.

Gentianaceae   **Gentian Family**

Gentiana rubricaulis Schwein. [closed gentian]. Uncommon, moist swales and shores.

Halenia deflexa (Sm.) Griseb. [spurred gentian]. Frequent, boreal forest.

Menyanthes trifoliata L. [bog buckbean]. Common, bogs; rare, lakeshores, ponds, and swamps.

Apocynaceae   **Dogbane Family**

Apocynum androsaemifolium L. [spreading dogbane]. Frequent, dry rocky openings along the ridge tops.

Convolvulaceae   **Morning Glory Family**

Convolvulus spithamaeus L. [low bindweed]. Uncommon, dry rocky clearings.

Hydrophyllaceae   **Waterleaf Family**

** *Phacelia franklinii* (R. Br.) Gray. Uncommon, rocky openings at Crystal Cove and Captain Kidd Island.

Boraginaceae   **Borage Family**

Cynoglossum boreale Fern. [northern wild comprey]. Uncommon, rocky openings and dry clearings; rare, jack pine stands.

Cynoglossum officinale L. [common hound's tongue]. Rare, clearing at Rock Harbor Lodge. Introduced.

Mertensia paniculata (Ait.) G. Don [lungwort]. Uncommon, margins of swamps and lakes.

Myosotis laxa Lehm. [forget-me-not]. Uncommon, clearing near old lighthouse, Rock Harbor. Introduced.

Myosotis scirpioides L. [forget-me-not]. Rare, recently collected by Thiele at Malone Bay.

Myosotis sylvatica Hoffm. Rare, but locally abundant where found. Brown found it under cultivation and rapidly spreading at Washington Island in 1930. It has since spread to the main island.

Labiatae   **Mint Family**

Dracocephalum parviflorum Nutt. [dragonhead]. Uncommon, dry rocky openings.

Galeopsis tetrahit L. [hemp nettle]. Frequent, recent burns, sandy shores, and disturbed sites.

Glechoma hederacea L. [ground-ivy]. Uncommon, moist banks and clearings.

Lycopus americanus Muhl. Frequent, moist shores and swamps.

Lycopus uniflorus Michx. Common, swamps and shores; uncommon, bog mats.

Mentha arvensis L. [field mint]. Frequent, swamps and shores of lakes and ponds.

Prunella vulgaris L. [self-heal]. Frequent, clearings; uncommon, boreal forest.

Satureja vulgaris (L.) Fritsch. [wild basil]. Frequent, clearings, meadows, and disturbed sites.

Scutellaria epilobiifolia A. Hamilton [skull-cap]. Frequent, lakeshores and banks.

Scutellaria lateriflora L. [mad-dog skullcap]. Uncommon, lakeshores.

Stachys palustris L. [woundwort]. Rare, collected only on wet soil near Huginnin Cove Trail.

Thymus serpyllum L. [creeping thyme]. Rare, rocky openings, McCargoe Cove campsite. Introduced.

Solanaceae   **Nightshade Family**

Chamaesaracha grandiflora (Hook.) Fern. [large white-flowered ground-cherry]. Rare, rocky openings.

Scrophulariaceae   **Figwort Family**

** *Castilleja septentrionalis* Lindl. [eastern paintbrush]. Common, rocky clearings and aspen woods. An arctic-alpine species.

Chelone glabra L. [turtlehead]. Uncommon, swamps.

** *Collinsia parviflora* Dougl. Rare, rocky openings along ridges. A western disjunct.

** *Euphrasia hudsoniana* Fern. & Wieg. Frequent, rock shore pools and crevices. An arctic species.

Linaria vulgaris Hill[butter and eggs]. Rare, gravelly beach at Grace Island.

Melampyrum lineare Desr. [cow-wheat]. Frequent, boreal forest and rocky clearings.

Mimulus ringens L. [monkey flower]. Rare, swamp at McCargoe Cove.

Scrophularia lanceolata Pursh [figwort]. Rare, collected only by Brown along trail to Lake Desor and at Lake Desor.

Verbascum thapsus L. [great mullein]. Frequent, dry rocky openings and clearings.

Veronica americana (Raf.) Schwein. [American brooklime]. Uncommon, swamps and swales.

Veronica arvensis L. Rare, disturbed aspen ridge near Rock Harbor Lodge. Introduced.

Veronica officinalis L. [common speedwell]. Rare, collected by R. Janke in grassy meadow near Windigo.

Veronica serpyllifolia L. [thyme-leafed speedwell]. Rare, moist soil.

Veronica verna L. Rare, collected in 1959 by Harold and Virginia Bailey. This was the first record for the United States and the second for North America. More recently collected at McCargoe Cove Camp by R. Janke.

Veronicastrum virginicum (L.) Farw. [culver's-root]. Rare, Washington Harbor.

Lentibulariaceae   **Bladderwort Family**

* *Pinguicula vulgaris* L. [butterwort]. Uncommon, mossy banks and rock shore pools and crevices. An arctic plant.

Utricularia cornuta Michx. Common, bog mats and muddy shores.

Utricularia gibba L. Uncommon, submersed in open water of ponds and lakes.

Utricularia intermedia Hayne. Abundant, submersed and often rooted in the mucky bottom of lakes, streams, swamps, ponds, and bogs.

Utricularia minor L. Uncommon, submersed in lakes and ponds.

Utricularia vulgaris L. Common, submersed in shallow water of ponds, lakes, streams, and bogs.

Plantaginaceae   **Plantain Family**

Plantago major L. [common plantain]. Uncommon, disturbed soil.

Rubiaceae   **Madder Family**

Galium asprellum Michx. [rough bedstraw]. Uncommon, moist swales and banks.

Galium boreale L. [northern bedstraw]. Rare, collected by Brown "near Washington Club."

Galium tinctorium L. Uncommon, bog mats and moist swales.

Galium trifidum L. Uncommon, moist banks of lakes and ponds and in swamps.

Galium triflorum Michx. [sweet-scented bedstraw]. Common, mixed forests; uncommon, swamps.

Caprifoliaceae   **Honeysuckle Family**

Diervilla lonicera Mill. [bush honeysuckle]. Abundant, rocky openings, mixed woods, and rock shore crevices.

Linnaea borealis L. [twinflower]. Common, boreal forest; frequent, mixed hardwood forests.

Lonicera canadensis Bartr. [Canada honeysuckle]. Frequent, jack pine stands and the boreal forest, increasing with forest maturity.

Lonicera dioica L. Uncommon, rocky openings and jack pine stands.

Lonicera hirsuta Eat. [hairy honeysuckle]. Uncommon, lake margins and swamps.

**   *Lonicera involucrata* (Richards) Banks [involucred honeysuckle]. Rare, near park headquarters at Mott Island, next to Rock Harbor Lodge, in dry woods 3/4 mile southwest of Rock Harbor Lodge, along the south shore of Tobin Harbor, along Lake Richie Trail, and along the Feldtmann Trail.

Lonicera oblongifolia (Goldie) Hook. [swamp fly honeysuckle]. Rare, collected from a swamp southwest of Daisy Farm.

Lonicera tatarica L. [tartarian honeysuckle]. Rare, introduced on Washington Island.

Lonicera villosa (Michx.) R. & S. [mountain fly honeysuckle]. Rare, moist shores and swamps.

Sambucus pubens Michx. [red-berried elder]. Abundant, burn sites; frequent, forests and rocky openings.

Symphoricarpos albus L. [snowberry]. Uncommon, inland rocky openings.

*   *Viburnum edule* (Michx.) Raf. [squashberry]. Common, boreal and mixed forests.

Viburnum trilobum Marsh. [high-bush-cranberry]. Uncommon, lake and stream margins, and thickets.

Campanulaceae   **Blue Bell Family**

Campanula aparinoides Pursh [marsh bell-flower]. Uncommon, margins and hummocks of lakes, ponds, and bogs.

Campanula rotundifolia L. [harebell]. Common, rock shore crevices; uncommon, rocky openings inland.

Lobelia dortmanna L. [water lobelia]. Uncommon, submersed or emersed in shallow water, rooted in sand or muck.

Lobelia kalmii L. Uncommon, crevices and pool of rock shores; rare, bogs.

Compositae   **Composite Family**

Achillea lanulosa Nutt. Uncommon, collected from the head of Rock Harbor, Mott Island, and the Lake Richie Trail.

Achillea millefolium L. [common yarrow]. Common, rocky openings and clearings.

Anaphalis margaritacea (L.) C. B. Clarke [pearly everlasting]. Frequent, rocky openings, clearings, and meadows.

Antennaria canadensis Greene. Uncommon, rocky openings, rock shore crevices, and dry clearings.

Antennaria munda Fern. Cited by Fernald (1933).

Antennaria neodioica Greene. Uncommon, grassy clearings, rocky openings, and rock shore crevices.

Antennaria plantaginifolia (L.) Hook. Uncommon, rocky openings.

** *Antennaria rosea* Greene. Rare, collected by Herma Baggley in 1940 from Caribou Island.

Antennaria rupicola Fern. Cited by Fernald (1933).

Arctium minus (Hill) Bernh. [common burdock]. Rare, disturbed sites.

Artemisia canadensis Michx. [wormwood]. Uncommon, rock shore crevices.

Artemisia caudata Michx. Rare, rock shore crevices, Passage Island.

Aster ciliolatus Lindl. Frequent, rocky openings and clearings.

Aster lateriflorus (L.) Britton. Uncommon, lakeshores and clearings.

Aster macrophyllus L. [big-leaf aster]. The most abundant ground cover species in all stages of boreal forest succession.

** *Aster modestus* Lindl. Rare, collected from the rocky shore at Siskiwit Lake and a field at Washington Harbor.

Aster ptarmicoides (Nees.) T. & G. Frequent, rock shores.

Aster puniceus L. Frequent, lakeshores, ponds, streams, and swamps.

Aster simplex Willd. Uncommon, swamps, sandy shores, and stream banks.

Aster umbellatus Mill. Frequent, swamps.

Bidens cernua L. Uncommon, bogs and swamps.

Centaurea cyanus L. [bachelor button]. Introduced near Rock Harbor Lodge and spreading slowly into nearby open fields.

Chrysanthemum leucanthemum L. [common daisy]. Frequent, rocky clearings and meadows.

Cirsium arvense (L.) Scop. [Canada thistle]. Frequent, clearings and rocky openings.

Cirsium muticum Michx. [swamp thistle]. Uncommon, stream and lake banks, and swamps.

Cirsium vulgare (Savi) Tenore [common thistle]. Rare, recent burns.

Crepis tectorum L. Rare. Collected once on a small island in Belle Harbor.

Erigeron annuus (L.) Pers. [dwarf fleabane]. Uncommon, rocky clearings and fields.

Erigeron canadensis L. [horse-weed]. Uncommon, clearings and disturbed sites.

Erigeron philadelphicus L. Rare. Collected from a creek bed two miles above Washington Harbor.

Erigeron strigosus Muhl. [daisy fleabane]. Frequent, rocky openings and dry clearings.

Eupatorium maculatum L. [joe-pye weed]. Frequent, shores of beaver ponds, lakes, and rivers.

Gnaphalium macounii Greene. Uncommon, rocky openings and meadows.

Hieracium aurantiacum L. [orange hawkweed]. Uncommon, clearings, Birch Island, Siskiwit Camp, Coyote Ridge, Rock Harbor Lodge, Mott Island, Greenstone Ridge 1 mile SW of Ishpeming Point, and the 1936 burn area.   Probably introduced.

Hieracium canadense Michx. [Canada hawkweed]. Frequent, rocky openings, clearings, and sandy beaches; uncommon, boreal forests.

Hieracium florentinum All. [king devil hawkweed]. Frequent, rocky clearings and meadows.

Hieracium scabrum Michx. Uncommon, rocky clearings and boreal forests.

Hieracium umbellatum L. Uncommon, rocky clearings, beaches, and birch forest.

Lactuca biennis (Moench) Fern. Uncommon, mixed forests and recent burn sites.

Lactuca canadensis L. Uncommon, recent burns and rocky openings.

**   *Lactuca pulchella* (Pursh) DC. [blue lettuce]. Rare, recent burns, and rocky clearings.

Matricaria matricarioides (Less.) Porter [pineapple weed]. Uncommon, clearings and disturbed sites.

Megalodonta beckii (Torr.) Greene. Uncommon, submersed in shallow lakes and slow streams.

Petasites palmatus (Ait.) Gray [sweet coltsfoot]. Frequent, swamps; uncommon, young forests.

Prenanthes alba L. [white-lettuce]. Uncommon, boreal forest; rare, swamps.

Prenanthes racemosa Michx. Uncommon, rocky openings and rock shore crevices.

Rudbeckia hirta L. [black-eyed susan]. Frequent, meadows and rocky clearings.

** *Senecio indecorus* Greene. Uncommon, dry, rocky openings.

Senecio pauperculus Michx. [ragwort]. Rare, rocky openings.

Solidago altissima L. Uncommon, clearings and rocky openings.

Solidago canadensis L. [Canada goldenrod]. Frequent, recent burns; uncommon, swamps and damp soil.

Solidago gigantea Ait. Uncommon, damp soil.

Solidago graminifolia (L.) Salisb. Frequent, swamps and shores; uncommon, rock shores.

Solidago hispida Muhl. Common, rock shore crevices; less common, ridge tops.

Solidago juncea Ait. Uncommon, clearings and rocky openings.

Solidago nemoralis Ait. Uncommon, rocky clearings.

Solidago purshii Porter. Uncommon, swamps and bogs.

Solidago randii (Porter) Britt. Uncommon, rocky clearings.

Sonchus arvensis L. [field sow-thistle]. Uncommon, rocky openings, clearings, disturbed sites, and sandy beaches.

Tanacetum vulgare L. [common tansy]. Uncommon, disturbed sites. Introduced.

Taraxacum officinale Weber [dandelion]. Frequent, clearings and disturbed sites.

Tragopogon pratensis L. [goat's beard]. Uncommon, clearings.

ACKNOWLEDGEMENTS

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PRESETTLEMENT FOREST OF
SOUTH-CENTRAL MICHIGAN

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Much of the forest of the southern portions of the Lower Peninsula of Michigan is characterized by upland species common and widespread throughout eastern North America. In this part of Michigan, two general forest types predominate; one is an assemblage dominated by oaks (*Quercus* spp.) and to a lesser extent hickories (*Carya* spp.) The other type is composed of beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*) (Braun 1950; Küchler 1964; Barnes & Wagner 1981). However, the original forest was largely destroyed. Prevailing forest types are represented mainly by woodlot remnants in varying states of disturbance (Dodge 1984).

Within the south-central Lower Peninsula, least disturbed upland stands are dominated by either sugar maple and beech or by combinations of white oak (*Quercus alba*), black oak (*Q. velutina*), red maple (*Acer rubrum*), and black cherry (*Prunus serotina*). These latter two species are not typically used in traditional descriptive labels of more xeric forest types within the region (for example, oak or oak-hickory). Ascendancy in dominance of red maple and black cherry is a result of a number of factors including woodlot cutting, grazing, and suppression of fire. Furthermore, tree species that are dominant in one of the two upland forest types are relatively uncommon in the other (Dodge & Harman 1985a).

These findings raise a number of questions. First, what species were characteristic in the forest of the south-central Lower Peninsula of Michigan just prior to the time of settlement? This period is significant because it predates widespread land clearing for agriculture and other forms of disturbance. Second, were sugar maple and beech and oaks segregated then as they are now or did they intermix more so than at present? Third, the previous study (Dodge & Harman 1985a) examined only a relatively small portion [533 km^2 (207 mi^2)] of the Lower Peninsula. If the region of investigation is significantly increased in area, what patterns of vegetation would be evident on the presettlement landscape?

Except for Veatch's (1959) map of presettlement vegetation, studies of the forest of aproximately 150 years ago in south-central Michigan are generally lacking. Parmelee (1953) as well as Dodge & Harman (1985a) examined General Land Office Survey records, but these notes were used only as a secondary source of information. Neither study attemped to reconstruct the nature of the presettlement vegetation. Veatch, however, did precisely this. His map of the presettlement forest of the Lower Peninsula is a valuable historical document, but the map has a number of weaknesses, some of which Veatch noted in his accompanying map text. First, the map is small-scale and it is necessarily much generalized. Second, it is qualitative in nature and each forest type is nominally

described by characteristic species. No quantitative measures such as frequency or importance value can be derived from the map. Third, as Veatch admitted, the map contains errors. Present patterns of vegetation, as I found in my 1984 study, do not correspond in all cases to his reconstruction. Moreover, Veatch's method of reconstruction is not explicitly stated. Although the primary basis of his mapping is the correlation between soil type, geomorphology, and forest type (Veatch 1928, 1931, 1959), he also used numerous historical sources, including the records of the General Land Office Survey. However, it is unclear to what extent and by what method he employed the surveyors' field notes.

In order to add to Veatch's (1959) work and answer the questions arising from my earlier study (Dodge & Harman 1985a), this investigation has three primary objectives: first, to describe statistically the species composition of the presettlement forest of south-central Michigan; second, to construct a series of maps displaying this statistical information, and third, to analyze the geographical and ecological relationships between beech, sugar maple, and oaks.

THE STUDY AREA

The region of investigation consists of five counties encompassing Eaton, Clinton, Ingham, Livingston, and Shiawassee Counties within the south-central portion of the Lower Peninsula (Figure 1). Total area is 7270 km^2 (2807 mi^2) or about 147,894 ha (365,440 a). The study area is subdivided into 80 townships, each approximately 90 km^2 (35 mi^2).

Regional climate is temperate-continental with warm, humid summers (Trewartha & Horn 1980). Mean annual temperature is approximately 9 C (48–49 F) and average annual precipitation is between 762–838 mm (30–33 in) throughout the study region (Michigan Department of Agriculture 1974a, 1974b).

Topography of the area is mainly a product of Wisconsinan glaciation and postglacial stream erosion. Till plain (or ground moraine) and complex end morainic systems associated with the Saginaw glacial lobe are the primary topographic features. However, the terrain of northeastern Clinton and northern Shiawassee Counties is unlike most of the region. This area is relatively flat, low-lying glacial lake plain which extends northeastward to Saginaw Bay (Leverett & Taylor 1915; Farrand 1982).

Soils within the region are texturally and taxomomically varied. Soils on moraines and till plains are mainly medium-textured loams and silt-loams. In contrast, coarser textured tills are associated with sandy clay-loams, sandy-loams, and loamy-sands. Meltwater channel and outwash plain sands and gravels are also prevalent throughout the region. Soil orders within the area include Entisols, Histisols, Inceptisols, and Mollisols, but Alfisols are most common. Hapludalphs are the most typical great group within the five counties and they are usually well drained. Somewhat poorly drained, poorly drained, and very poorly drained soils occur throughout the area, especially on till and lake plains of northern Clinton and Shiawassee Counties (Threlkeld & Feenstra 1974; Pregitzer 1978; Michigan State University et al. 1981; Farrand 1982; Albert et al. 1986).

Clinton   **Shiawassee**

LEBANON	ESSEX	GREEN-BUSH	DUPLAIN	FAIR-FIELD	RUSH	NEW HAVEN	HAZEL-TON				
DALLAS	BENGAL	BINGHAM	OVID	MIDDLE-BURY	OWOSSO	CALE-DONIA	VENICE				
WEST-PHALIA	RILEY	OLIVE	VICTOR	SCIOTA	BENNING-TON	SHIA-WASSEE	VERNON				
EAGLE	WATER-TOWN	DE WITT	BATH	WOOD-HULL	PERRY	ANTRIM	BURNS				
SUN-FIELD	ROXAND	ONEIDA	DELTA	LANSING	MERIDIAN	WILLIAMS-TON	LOCKE	CONWAY	COHOC-TAH	DEER-FIELD	TYRONE
VERMONT-VILLE	CHESTER	BENTON	WINDSOR	DELHI	ALAIE-DON	WHEAT-FIELD	LEROY	HANDY	HOWELL	OCEOLA	HART-LAND
KALAMO	CARMEL	EATON	EATON RAPIDS	AURELIUS	VEVAY	INGHAM	WHITE OAK	IOSCO	MARION	GENOA	BRIGHTON
BELLEVUE	WALTON	BROOK-FIELD	HAMLIN	ONON-DAGA	LESLIE	BUNKER HILL	STOCK-BRIDGE	UNADILLA	PUTNAM	HAMBURG	GREEN OAK

0   mi.   10
0   km.   10

MICH

Eaton   **Ingham**   **Livingston**

Figure 1. Five-county study area.

METHODS

Data Aquisition

Presettlement tree species data were obtained from records of the General Land Office Survey on file in the Real Estate Division, Michigan Department of Natural Resources in Lansing. These surveyors' field notes have been a source of information for numerous studies of the original vegetation of Michigan (Dick 1937; Kenoyer 1943; Hushen et al. 1966; Nutter & Harman 1973; Kapp 1978; Brewer et al. 1984; Whitney 1986; Medley & Harman 1987). Detailed histories, descriptions, and analyses of original surveyors' field methods are available in Bourdo (1956) and White (1983).

General Land Office surveys of 77 townships within the study region were conducted between 1823 and 1831. Two townships, Burns (T5N, R4E) and Vernon (T6N, R4E), were subdivided in 1848 as a result of the survey of the Keetchewanndangenink Reserve (Indian Reserve). In addition, Greenbush Township (T8N, R2W) was resurveyed in 1852 apparently because of an inaccurate and likely fraudulent survey in 1831. By 1852, the resurvey party could not locate numerous old bearing trees, posts, and lines, possibly because they did not exist in the first place. Settlers also destroyed much of the original forest cover by the time of the resurvey. As a result, only a relatively few bearing and line trees were recorded in the field notes of this township.

I recorded the species of all bearing (or witness) and line (or station) trees within each township in the five county area. In order to enhance accuracy of data collection, I did not include in the sample those trees along township perimeters because such individuals might be considered as straddling two townships. Thus, I mitigated the possibility of twice observing and counting an individual by not including these trees. Furthermore, by enumerating data for individual townships, I was able to construct specialized statistical maps depicting the collected areal data. A sample size of 80 townships also is sufficiently large for statistical analysis.

Problems sometimes arose in the interpretation of surveyors' tree names, for example, "yellow" oak, "lynn," "whitewood," "elm," "poplar," and "ash." In cases of archaic names, I referred to a number of sources for conversions to modern species designations (Britton & Brown 1913; Fowells 1965; Miller & Lamb 1985). But I did not decipher generic labels like "elm" or "ash." Although it is sometimes possible to determine the species of a particular individual by using topographic maps to assess the environment of a specific site, such a determination is not always reliable. In any event, I do not consider a more precise species designation in these cases as critical to this investigation.

Data Processing

Collected species data were converted to frequencies (N of individuals of species X/N of all individuals). Frequency in this case is a measure of the probability, ranging from 0 to 1, of observing a given species within a township (Brower & Zar 1977). Thus, for each species there are 80 frequency measures, one for each township. These measures were also averaged to obtain mean frequencies for a number of species throughout the five county study area.

In order to simplify the frequency data, I classed individual species frequencies for each townships with JENKS. JENKS is a single variable clustering routine based on analysis of variance and it produces classes with minimum within-class variance and maximum numerical distance between classes (Groop 1980). Agglomerative clustering techniques of this type produce relatively sharply defined upper and lower class boundaries and they do not seriously misclassify observational units (Williams 1971; Hill et al. 1975).

Instead of classing all species, I selected only relatively common species within the regional presettlement forest. In the case of tamarack, (*Larix laricina*), black spruce (*Picea mariana*), and northern white-cedar (*Thuja occidentalis*), I combined these species into one group, "lowland conifers." This not only further simplified a large data set, but these species also grew on similar sites at the time of the surveys. Moreover, frequencies of black spruce and northern white-cedar were very low and were recorded in only a few townships. I followed this same simplification proceedure by combining frequencies of white, black, northern red (*Quercus rubra*), and chinkapin (*Q. muehlenbergii*) oaks to form an "upland oaks" category. Similarly, frequencies of beech and sugar maple also were combined.

Classed species frequencies were displayed on choropleth maps in order to evaluate the distribution of species throughout the study area. These quantitative area maps employ shadings (or gray-tones) that are assigned to individual data classes with upper and lower class limits. Shades, in turn, are applied to each data enumeration unit (or township in this situation). Application of gray-tones is dependent on an area's data value, the class in which the value is assigned, and the corresponding shade of the class. Four classes, as calculated by the JENKS algorithm, were used on each map. Four-class choropleth maps reduce data complexity and fall within the recommended range of 4 to 6 classes (Dent 1985).

Because statistical correlation is an appropriate analytical measure of relationships between variables (Connolly & Slukin 1971), I used the product-moment coefficient of correlation to assist in the goal of assessing the presettlement geographical and ecological interrelationships between beech and sugar maple and oaks. In this case, the analyzed variables are the frequencies of beech and sugar maple as well as the combined frequencies of upland oaks.

RESULTS

I obtained a sample of 21,115 trees for the entire five county area. Township sample size ranged from 333 trees in Lansing (T4N, R2W) to 115 in Greenbush (T8N, R2W), with the average sample for each of the 80 townships consisting of 264 trees.

Upland oak species with an average combined frequency of 0.33 were the most common species within the study area at the time of the early 19th century surveys. White and black oak were particularly common constituents of this group (Table 1). Upland species such as northern red oak and "yellow" or

chinkapin oak, as well as lowland swamp white oak (*Quercus bicolor*) and pin oak (*Q. palustris*) were also members of the forest. However, they were relatively uncommon; surveyors observed the latter three species in only 12 townships. The general low frequency of hickory, a typical oak associate, in the presettlement forest is notable. This relative rarity was true not only in areas characterized by oaks, but also in areas dominated by beech and sugar maple.

Beech and sugar maple were relatively abundant in the region (Table 1). Beech, according to the surveyors, was nearly as common, on average, as white oak. Moreover, beech had a frequency greater than two times that of sugar maple. Other maples are not differentiated in the surveys, but they are most likely red maple. These maples were usually observed on uplands and in swampy environs, not along rivers as would usually be true of silver maple (*Acer saccharinum*). Red maple and black cherry were relatively infrequent elements of the forest throughout the region (Table 1). This was the case not only in townships characterized by beech and sugar maple, but also in townships dominated by oaks. Many other species were constituents of the regional upland forest, but their frequencies were generally very low. Some of these are tulip tree (*Liriodendron tulipifera*), tupelo (*Nyssa sylvatica*), black walnut (*Juglans nigra*), butternut (*J. cinerea*), aspen (*Populus* spp.), ironwood (*Ostrya virginiana*), hornbeam (*Carpinus caroliniana*), hawthorne (*Crategus* spp.), and dogwood (*Cornus florida*).

The combined frequencies of elm (*Ulmus* spp.), black ash (*Fraxinus nigra*), and lowland conifers (black spruce, tamarack, and northern white-cedar) (Table 1) are indicative of the numerous poorly drained lowlands, swamps, and bogs prior to settlement.

When analyzed at the individual township level, however, upland oaks (white, black, northern red, and chinkapin) were not nearly as dominant throughout the region as their average frequency indicates. Oaks were concentrated in the eastern portions of the study area, especially in Livingston County (Figure 2). Other areas of concentration were southern Shiawassee County and southwestern townships of Ingham and Clinton Counties. In contrast, oaks were generally infrequent in townships within the western remainder of the region.

Where oaks were uncommon, beech and sugar maple were regional dominants (Figure 3). The upland oak and sugar maple-beech maps are near mirror images of one another; moreover, correlation corroborates this visual impression. A strong statistical relationship exists between beech and upland oaks as well as sugar maple and upland oaks; both relationships have "high" (Connolly & Sluckin 1971, p. 54) negative correlation coefficients (Table 2). Furthermore, the negative coefficient of correlation between the combined township frequencies of sugar maple plus beech and upland oaks is "very high" (Connolly & Sluckin 1971, p. 54).

The distributions within the study region of a number of relatively common species are noteworthy. Basswood (*Tilia americana*) (Figure 4) was generally infrequent in townships dominated by oaks, but it was more abundant in areas characterized by beech and sugar maple. However, highest frequencies of basswoood were concentrated in northernmost townships. Although no general trend in elm abundance is apparent on the choropleth map, northern Eaton

TABLE 1. Mean tree species frequency within the study region presettlement forest (N = 80 townships).

Species	Mean Frequency
Quercus alba	0.222
Fagus grandifolia	0.197
Quercus velutina	0.091
Acer saccharum	0.082
Ulmus spp.	0.074
Lowland conifers[1]	0.063
Fraxinus nigra[2]	0.051
Tillia americana	0.047
Fraxinus americana[2]	0.034
Acer spp.	0.031
Carya spp.	0.021
Prunus serotina	0.005
Other spp.	0.063

[1]*Larix laricina, Picea mariana,* and *Thuja occidentalis.*
[2]N = 54 and 57 respectively. Otherwise, "ash" not differentiated.
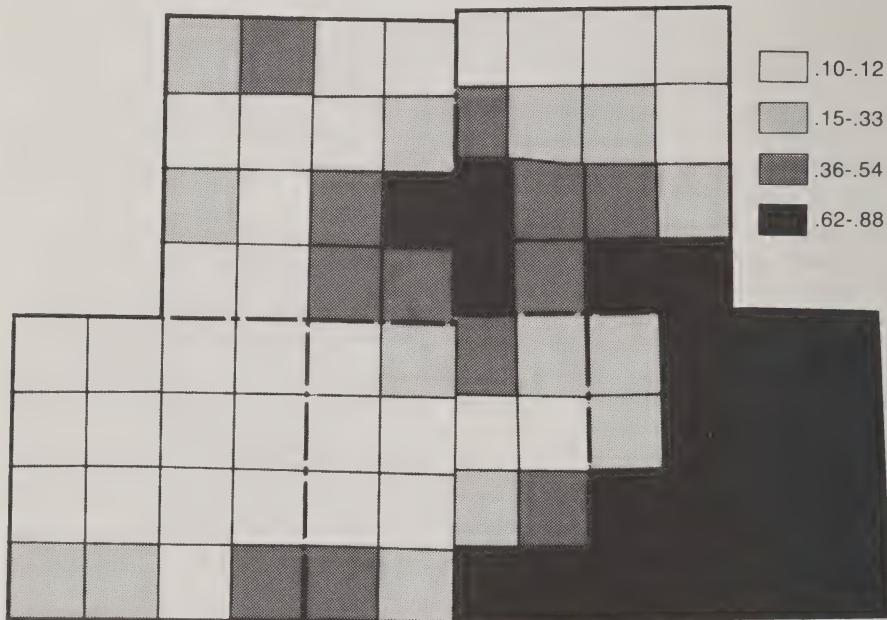

Figure 2. Four-class choropleth map of UPLAND OAK (white, black, northern red, and chinkapin) freuqency within the study area presettlement forest. Numbers represent upper and lower class limits. For example, a township with an oak frequency of 0.79 would be a member of the highest class (0.62–0.88). As a result, the township would be shaded with black.

County had the highest frequency of elm while lowest frequencies were in oak-dominated townships (Figure 5). In addition, nearly all townships in Shiawassee County had relatively higher frequencies of elm. Distribution of
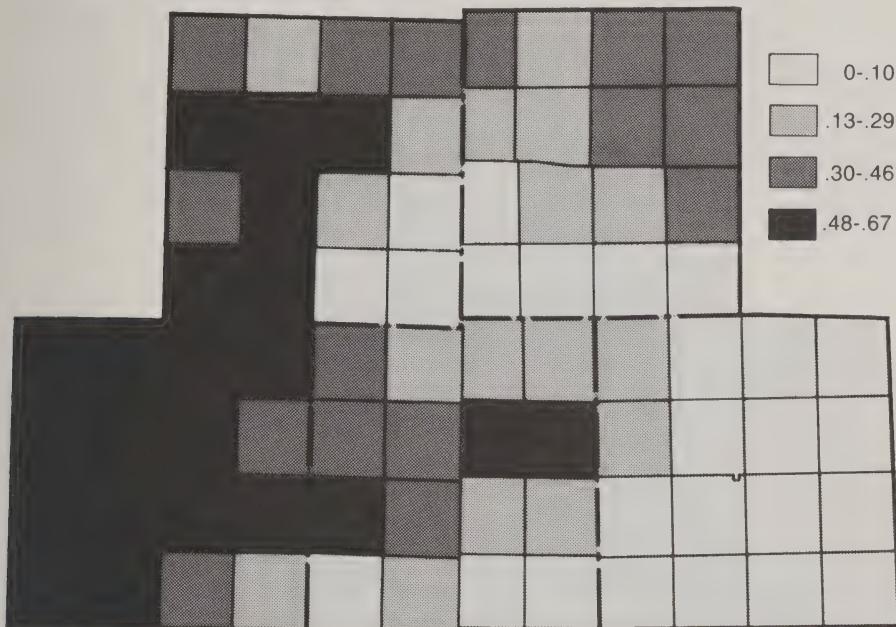
Figure 3. Four-class choropleth map of BEECH-SUGAR MAPLE frequency with the study area presettlement forest. Numbers represent upper and lower class limits.

lowland conifers was patchy and associated with scattered swamps, bogs, and ponds within the region (Figure 6). These conifers were most abundant in Ingham County. Tamarack was singualrly common in the "terrible tamarack swamp," so described by Henry Park, the surveyor of the area, in Meridian (T4N, R1W) and Bath (T5N, R1W) Townships. (This swamp is now called Chandler Marsh.) Extensive stands of tamarack occured elsewhere within the region but a remarkable one was in Owosso Township (T7N, R2E). This swamp was characterized by the surveyor, William Brookfield, as "wretched swamp, stinking indeed . . . and miserable not even fit for wolves to inhabit." Coniferous bogs and swamps were not prefered survey sites of early surveyors.

Other than conifers of swamps and bogs, tree species with more northern centers of distribution were relatively uncommon within the region. White pine (*Pinus strobus*) was recorded in northern Clinton County. In Dayton Township (T8N, R1W) this species grew on "poor pine land" and white pine was observed in swamps of Greenbush Township (T8N, R2W). "Poplar" and "aspen" (*Populus* spp.) occurred throughout the study region, but neither were very common. Black ash (*Fraxinus nigra*) also was recorded in wetlands throughout the five county area. "Birch" was observed in all counties except Livingston and it was probably paper birch (*Betula papyrifera*) in nearly all cases. It apparently was a member of wet lowland communities. Yellow birch (*B. alleghaniensis*) was recorded in the northern tier of townships of Clinton County. It was not differentiated in other parts of the study area even though it ranges south through southern Michigan to the Ohio border (Fowells 1965; Voss 1985).

TABLE 2. Results of correlation between presettlement frequencies of beech, sugar maple, and oak (N = 80 townships).

variables	r	r^2	t	df	p	std. error
sugar maple vs. oak	−0.79	0.62	11.42	78	$<10^{-6}$	0.042
beech vs. oak	−0.88	0.77	16.18	78	$<10^{-6}$	0.025
sugar maple-beech vs. oak	−0.93	0.86	21.73	78	$<10^{-6}$	0.015

Note: All correlation coefficients are significant.
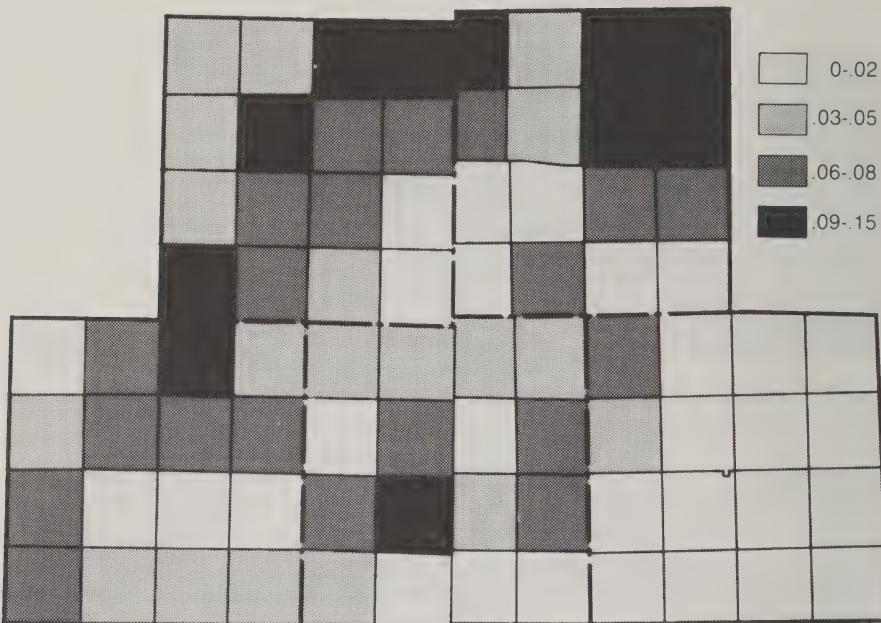
Figure 4. Four-class choropleth map of BASSWOOD frequency within the study area presettlement forest. Numbers represent upper and lower class limits

A few individual trees within the presettlement forest deserve mention. Two examples of Ohio buckeye (*Aesculus glabra*) were recorded along the Grand River in Eaton Rapids (T2N, R3W). Although this is very near the northern limit of its range, Voss (1985) reported a modern specimen in Clinton County. A black walnut, 2.1m (7ft) in diameter was a line tree in Aleidon Township (T3N, R1W). And in Owosso Township (T7N, R2E) William Brookfield described a white oak 50 links in circumference [10m (33ft)]. He estimated the trunk was without branches to a height of 18.3m (60ft). Furthermore, he calculated that this tree would yeild 1000 split fence rails.

Despite my focus on the presettlement forest of south-central Michigan, I cannot disregard the remarkable number of surveyors' references to "prairie," "wet prairie," and savanna. They described the latter type of vegetation in numerous ways: "oak barrens," "thinly timbered with oak," "oak openings," "plains with very little timber," and "oak but very scattering" among others.
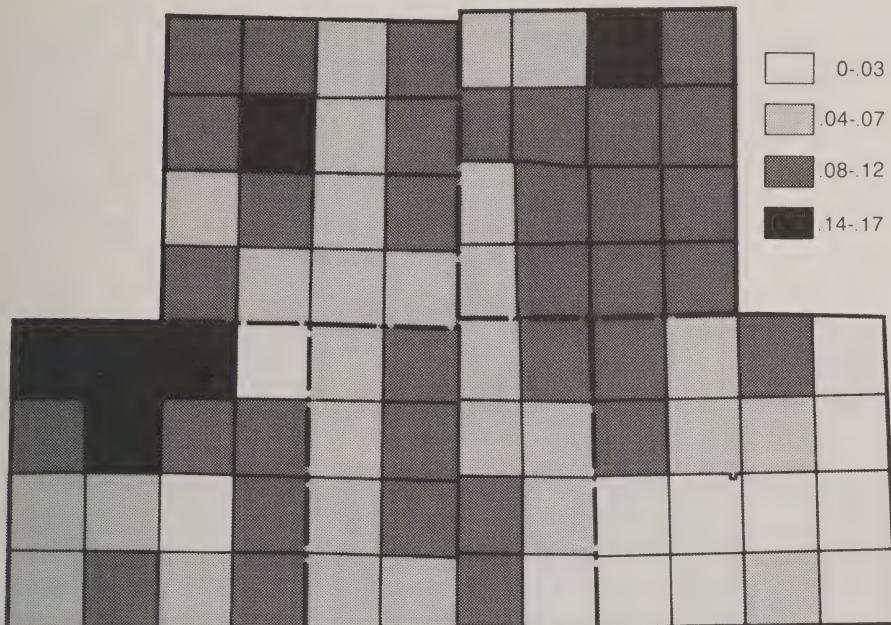
Figure 5. Four-class choropleth map of ELM frequency within the study area presettlement forest. Numbers represent upper and lower class limits.

Figure 7 demarcates townships where surveyors made explicit reference to pairies and "openings."

DISCUSSION

Presettlement Forest Patterns

Beech and sugar maple were particularly associated with ground moraine and medium textured tills which characterize Eaton and western Ingham Counties. Upland soils of this region are principally related to the Marlette-Capac-Owosso soil association. These loamy soils tend to be well to somewhat poorly drained. Also, they have high available water capacity and moderate to moderately slow permeability (Feenstra 1978; Barnes et al. 1979; Michigan State University et al. 1981). Upland oaks, in contrast, occupied glacial outwash sands and gravels and moraines composed of coarse textured till. Boyer, Fox, Oakville, Oshtemo, and Spinks soils form combinations of various soil associations within this region. These are well drained, moderately coarse to coarse textured sands and gravels with low to moderate available water capacity. Permeability is moderate to rapid (Endberg & Austin 1974; Michigan State University et al. 1981).

These findings are consistent with observations elsewhere in southern Michigan: beech and sugar maple occupy mesic sites whereas upland oaks are
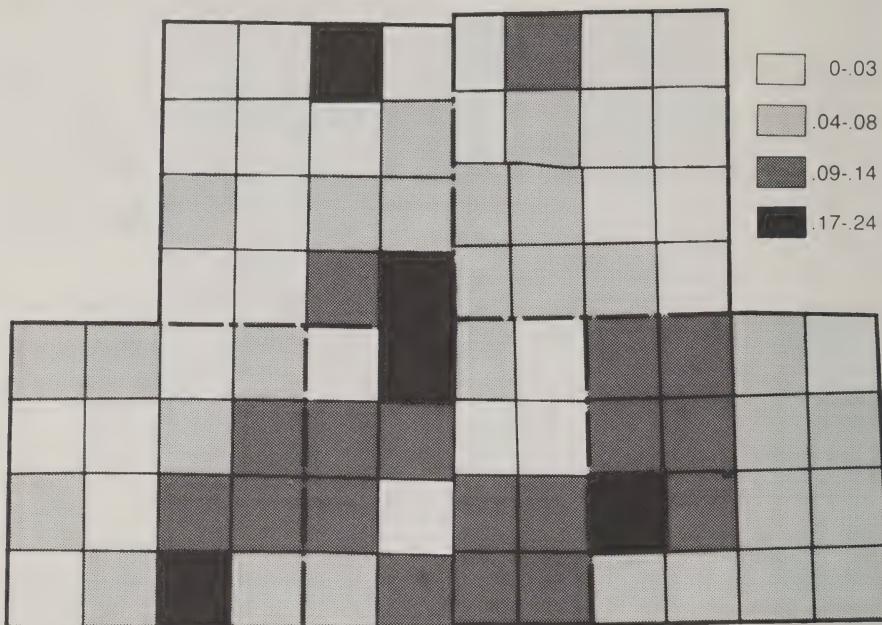
Figure 6. Four-class choropleth map of LOWLAND CONIFER (tamarack, black spruce, and northern white-cedar) frequency within the study area presettlement forest. Numbers represent upper and lower class limits.

located on more xeric sites (see Dodge 1984). Nevertheless, my study region differs from other areas in the southern Lower Peninsula in that oaks were also dominant on medium textured tills and associated loamy soils. This was especially so in northern Livingston, eastern and southern Ingham, as well as southern Shiawassee and southeastern Clinton Counties. These portions of the study area are characterized by loamy soils of the Marlette-Capac association, an association similar to that which characterizes the beech-sugar maple region in the western portion of the study region. Moreover, the transititon between areas characterized by oaks and areas dominated by beech and sugar maple was abrupt. A relatively narrow zone of transition in the southern tier of three counties trended northeastward through the townships of Leslie (T1N, R1W) and Ingham (T2N, R1E), eastward through Handy Township (T3N, R3E) and thence northwestward through the townships of Locke (T4N, R2E) and Williamston (T4N, R1E). Modern oak and sugar maple-beech woodlots in northeastern Ingham County are separated by a sharp geographic boundary (Dodge & Harman 1984a, 1984b) and this division appears to be a relict of presettlement forest patterns. Thus, this evidence coupled with the results of correlation demonstrate that there was little admixture of upland oaks with sugar maple and beech within the presettlement forest of the south-central Lower Peninsula.

I cannot definitively answer the question as to why the transition between these forest types was so abrupt. Nor is it clear why oaks dominated large areas underlain by soils that typically support beech and sugar maple. This problem

was the object of previous investigations (Dodge 1984; Dodge & Harman 1985b) and it is very likely related to differing subsoil lithology beneath areas of oak and beech-sugar maple forest. Further investigation of this matter is in progress.

Basswood's greater frequency in northern townships within the region is most likely related to poor drainage on lacustrine plains and nearly level till plains of northern Shiawassee Counties. Kapp (1978) observed this same relationship between basswood, drainage, and topography within the presettlement forest on relict plains of glacial Lake Saginaw in Montcalm County. Increased frequency of basswood within beech-sugar maple forest of the northern Lower Peninsula also is related to drainage for basswood is more abundant in lowland, more poorly drained areas (Braun 1950).

The distribution of elm is not so readily explained. Low frequency of elm in Livingston County is related to the high frequency of oak in this area. Soils in the eastern part of the study region are characteristically coarse textured with low water holding capacity. American elm (*Ulmus americana*) grows poorly on these soils (Fowells 1965). Elm frequency generally increases northward through Shiawassee and Clinton Counties and this is very much related to poorer drainage on fine textured soils of till and lake plains. However, I cannot explain the cluster of high elm frequency in northwestern Eaton County. Soils and geomorphology within these townships are similar to nearby townships with relatively low frequency of elm. This abundance of elm may be associated with floodplains and banks of the Thornapple and Grand Rivers and their tributaries. However, rivers elsewhere in the region, the Looking Glass, Maple, Red Cedar, and Shiawassee, are not associated with higher frequencies of elm. This problem may be in need of more investigation.

Composition of the Presettlement Oak Forest.

The composition of presettlement oak forest within south-central Michigan was much different from the species makeup of modern oak-dominated woodlots. Red maple and black cherry are very common in the modern canopy, but they were relatively rare in the forest of 150 years ago. Red maple, assuming "maple" is primarily this species, had a mean frequency of 0.031 throughout the study area and in only 9 townships was its frequency greater than 0.06. In Livingston County where oaks dominated the upland forest, frequency of red maple was less than 0.02. Black cherry was even less common for its average frequency throughout the area was about 0.005. The highest frequency of 0.03 occured in only one township. Livingston County also had a very low frequency of black cherry (0.003).

The relatively rapid rise in the importance of red maple and black cherry within modern oak woods has numerous causes, but suppression of wildfire is particularly important (Dodge & Harman 1985a). Both species are readily injured and killed by fire or the effects of disease and rotting as a result of fire scarring. Therefore, they are unable to outcompete other more robust species such as oaks in areas with frequent fires. But decreased fire frequency increases the probability of survival of red maple and black cherry seedlings (Fowells 1965; Burns 1983). As a result, these species eventually entered the canopies of
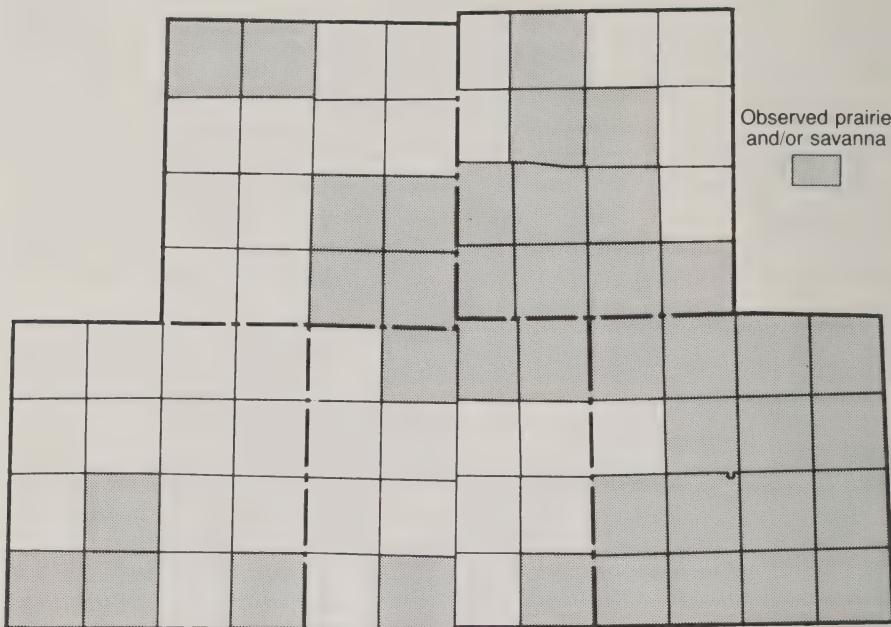
Figure 7. Study area townships wherein General Land Office surveyors recorded PRAIRIE and/or OAK SAVANNA vegetation.

postsettlement oak woods. In addition, woodlots in south-central Michigan are not usually clear cut; instead, individual trees are removed for timber and firewood. This sporadic removal of individual canopy trees rather than clear cutting perpetuates a closed canopy. Therefore, more shade-tolerant individuals are further able to outcompete oaks, and stands become even more characterized by species such as red maple (Burns 1983).

Hickories also were not common in oak forest at the time of settlement. Average frequency of hickories throughout the area was only 0.021 and exceeded 0.05 in only 5 townships. And hickory had a remarkably low frequency of 0.02 in oak-dominated Livingston County. Hickories may have been uncommon because they too are readily damaged by fire, especially pignut hickory (*Carya glabra*) and shagbark hickory (*C. ovata*), the most common hickories of southern Michigan uplands (Fowells 1965; Barnes & Wagner 1981). Frequent fires would have favored white and black oaks which, although susceptable to fire injury, are vigorous sprouters, rapid growers, drought-tolerant, and long-lived (Fowells 1965). As a result of this low frequency of hickory, oak-hickory is a misnomer for much of the presettlement forest within the study region.

SUMMARY AND CONCLUSIONS

This investigation yielded two major results. First, beech and sugar maple were not common associates of oaks. Moreover, the boundary between beech-sugar maple and oak-dominated forest

was abrupt. Based on results of correlation and map analysis, transition forest between beech-sugar maple and oak forests was not extensive, probably a few miles wide at most. In numerous cases, as described in the surveyors' field notes, oak forest graded almost immediately into forest dominated by beech and sugar maple. These findings differ little from the results of my previous studies (Dodge & Harman 1985a, 1985b). Second, presettlement oak forest was unlike its modern analogue. Red maple, black cherry, and hickories were not common species in the original forest and their rise in importance is most closely related to suppression of wildfire and sivicultural practices.

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FORCING WINTER ROSETTE PLANTS FOR CLASS USE

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Since our earlier paper on the use of plant materials for winter taxonomy classes (1983) we have done further experiments using species that form winter rosettes. The great value of these plants is that the rosettes are easy to recognize late in the year when needed, they can all be dug at the same time of year, and when properly forced can be brought to flower easily and quickly compared to most seed-grown plants. We used perennials, bi- and triennials, and winter annuals in the experiment. Winter annuals are plants whose seeds germinate in mid to late summer, form rosettes which survive the winter, and bloom in early spring. We experimented previously with several rosette-forming plants, at which time we found that not all species bloomed readily. The aim of the present work was to determine whether common winter rosette plants could be forced easily for teaching purposes. We tried as many species as we could dig in adequate numbers within easy reach of the Twin Cities, although space limitations in the greenhouse required that we keep the number of individual plants per species to a minimum.

Most of the work reported on here was done in 1985–86, but some relevant work from previous years is also included. All species were grown both with and without a cold treatment to determine if vernalization was necessary to induce bloom. It is well known that vernalization is a requirement for flowering in many plants (Halevy 1985). Because of our earlier successful experiment with this procedure (see below) and because we were equipped to provide a cold treatment, we used the process in our experiments. The period utilized was seven weeks in all cases except as noted in the table, for reasons given below. We did not experiment with different day lengths, with one exception.

In 1985 all plants were dug in the field during October, potted, and moved to an outdoor holding area; the handling differed somewhat in previous years. In the case of late-blooming species the plants selected were those without flowers when possible. In a few instances flowers and, when practical, flower buds were removed at time of collection. On October 21 those plants which were not to be vernalized were moved into a greenhouse where the day and night temperatures were about 75° and 65°F respectively, and the natural daylight was supplemented by HID sodium lamps set on 16 hour days and 8 hour nights. The rest of the plants remained outside until Nov. 1 when they were placed in a dimly illuminated cold room kept at 40°F. After seven weeks these plants were moved to the same greenhouse as the first group.

The period of seven weeks was determined by experiments with *Sisymbrium loeselii* and *S. altissimum* done in 1978. At that time we had numerous rosettes of these species, raised from seed, which would not bolt under the greenhouse conditions described above. By placing them in the cold room and withdrawing them two at a time at weekly intervals we found that *S. loeselii* plants would bolt

TABLE 1

Species[1]	Growth habit	No. of plants	Days to peak bloom[2]	Comments[3]	No. of plants	Days to peak bloom after cold treatment[2]	Comments[3]
Achillea millefolium	Perennial	4	71–84	Good	5	49–70	1 plant did not bloom. All others good.
Arabis divaricarpa	Biennial (?)						
Field soil		2	157, 161	Good	2	82, 91	Good
Potting soil		3	154–169	Good	3	65–68	Good
Barbarea vulgaris	Winter annual	3		None flowered	4	48–129	Poor: 2 plants with deformed inflorescence & few flowers. Requires cold.
Barbarea vulgaris (1984–85)		0			3	ca. 45	83 days vernalization. Good.
Berteroa incana	Biennial	5	97–182	Satisfactory	5	17, 66–81	Satisfactory. Slightly better with vernalization.
Capsella bursa-pastoris	Annual or winter annual	4	20–34	Poor, 3 plants diseased	3	14, 24	Poor this year. Few flowers, 1 plant did not bloom. Flower buds formed in cold room. The species has been good in previous years.
Centaurea maculosa	Biennial or short-lived perennial	6	113–149	Very good	7	87–91	Very good
Chamomilla suaveolens	Annual or winter annual	5	73–94	Good, peak maintained 1–2 weeks	5	39–53	Good. 1 diseased plant did not bloom (aster yellows). These and the unvernalized plants grew vegetatively in the cold room.

Species	Life cycle	No.	Days	Evaluation	No.	Days	Evaluation
Crepis tectorum	Winter annual or biennial	5	127	Poor, 1 plant bloomed, 2 diseased (aster yellows)	3	64, 91	Good. 1 diseased plant did not bloom (aster yellows).
Crepis tectorum (1984–85)		0			4	45–52	75 days vernalization. Good
Cynoglossum officinale	Biennial	4		None flowered	4	51–53	Very good. 1 plant did not bloom. Requires cold.
Descurainia sophia (1984–85)	Winter annual	4		None flowered	4	56–86	54 days vernalization. Good. Requires cold.
Erigeron annuus	Winter annual	4	147–164	Satisfactory. 1 plant diseased (aster yellows)	5	82–83	Good.
Gnaphalium obtusifolium	Biennial						
Field soil		2	147, 157	Good	3	109–128	Good.
Potting soil		2	138, 142	Good	3	108–114	Good.
Grindelia squarrosa	Biennial or perennial	5		None flowered	5	103–122	Very good. Requires cold.
Hieracium aurantiacum	Perennial						
Field soil		2	77, 99	Satisfactory	1	70	Satisactory
Potting soil		2	77, 84	Satisfactory	3	62–66	Satisfactory
Oenothera biennis	Bi– or triennial	6	100–157	Good. Few flowers at one time. 1 plant died without flowers	7	78–101	Good. few flowers at one time.
Plantago major	Perennial	4	161–175	Good, but short blooming period	4	70–77	Good, but short blooming period.
Ranunculus abortivus	Winter annual or short-lived perennial	4	81–218	Good	4	66–94	Good.

TABLE 1 cont.

Species[1]	Growth habit	No. of plants	Days to peak bloom[2]	Comments[3]	No. of plants	Days to peak bloom after cold treatment[2]	Comments[3]
Rorippa islandica	Winter annual or short-lived perennial	5	154–169	Satisfactory. 2 diseased plants did not bloom.	6	72–94	Good. 1 diseased plant did not bloom.
Rorippa islandica (1984–85)		2		None flowered	2	ca. 87	54 days vernalization. Good.
Rudbeckia hirta	Short-lived perennial						
Field soil		2	126	Good	3	82–91	Good.
Potting soil		2	99, 125	Good	3	87, 93	Good.
Silene cserei	Biennial	6	88–135	Very good	6	65–71	Very good.
Silene pratensis (Lychnis alba)	Annual to perennial	4	76–106	Satisfactory. 1 plant did not bloom	5	56–81	Very good.
Silene pratensis (1984–85)		2	158	Poor. 1 plant did not bloom	2	ca. 69	54 days vernalization. Very good.
Sisymbrium altissimum (1978)	Winter annual	15		None flowered.			
S. altissumum, plants from preceding group of 15 later vernalized. See text.					2	ca. 55	35 days vernalization. Poor. 1 plant did not bloom. Requires cold.
S. altissimum, as above.					3	ca. 55	42 days vernalization. Poor. 2 plants did not bloom. Cold period insufficient.
Sisymbrium loeselii	Winter annual	2		None flowered	2	50, 70	Very good. Requires cold.

Species	Habit	n	Result	Days	n	Days	Result
Sisymbrium loeselii (1978)		20	None flowered.				
S. loeselii, plants from preceding group of 20 later vernalized. See text.					2	ca. 49	42 days vernalization. Good.
S. loeselii, as above.					2	ca. 49	49 days vernalization. Good.
Taraxacum officinale	Perennial	4	Satisfactory. Few flowers	35–102	4	24–27	Satisfactory. Few flowers.
Thlaspi arvense	Annual or winter annual						
Incompletely dormant (see text)		5	Good	17–41	3	17–18	Good. Flower buds formed in cold room, some opened, inflorescence did not elongate.
Fully dormant		2	Good	52, 62	3	27–32	Good. No flower buds formed in cold room.
Verbascum thapsus	Bi– or triennial	5	None flowered		5		None flowered. Requires cold.
V. thapsus, unvernalized plants from first trial later given 77 days vernalization. See text.		2	See text		2	58, 62	Good.
V. thapsus, vernalized plants from first trial later given 77 days additional cold treatment					2	52, 54	Good.

[1]The year of the experiment was 1985–86 and the vernalization period 49 days unless otherwise noted.

[2]All plants bloomed unless otherwise indicated.

[3]The terms "satisfactory", "good", and "very good" are value judgements of the overall worth of these plants as class material.

with six or more weeks of vernalization while some but not all plants of *S. altissimum* bloomed with five or six weeks. We concluded that seven weeks should be sufficient vernalization for most plants. However, we later learned that this period was insufficient for two species in our experiment, *Barbarea vulgaris* and *Verbascum thapsus*.

The *Barbarea vulgaris* bloomed poorly, that is, the flowers were few and the inflorescence not always typical, but other plants of this species did well with nearly twelve weeks of cold in 1984–85. No *Verbascum thapsus* plants bloomed with or without the seven-week cold period. After it was clear that the plants would not bloom, some were moved to a room with a shorter day length, which brought no results. At the same time two plants from the vernalized group and two from the non-vernalized group were moved into the 40°F cold room for eleven weeks. All four additionally vernalized plants flowered after being returned to the greenhouse. None of the other plants bloomed, including two controls that had no second treatment. These results agree with those of Gleir & Caruso (1973, 1974), who used a cold period of twelve weeks to demonstrate the need for vernalization in this plant. However, the factor of plant size could have affected the foregoing results. Gross (1981) has shown that larger plants of this species are more likely to bloom than smaller ones and it is possible that the size threshhold for *V. thapsus* was crossed during their greenhouse growth. Our plants were about 13–18 cm in diameter when first potted but grew steadily in the greenhouse and were much larger when put in the cold room the second time for the eleven-week vernalization.

All 26 of the species in the experiment bloomed after vernalization, although *Verbascum thapsus* needed special treatment, as just described. In 19 species at least some plants flowered without vernalization. Seven species bloomed only after a cold period. In five, at least some plants bloomed under each treatment but vernalization was required to produce sufficient useable flowers. Fourteen species flowered about equally well with both treatments. The table supplies complete data including comments on flower quality and useability for teaching for each species tested.

It seems probable that those plants requiring vernalization as well as those that flowered more fully after vernalization were given a treatment approaching their optimum, on the theory that optimum conditions would promote optimum flowering. We made no attempt to determine the optimal blooming conditions for those species that bloomed about equally well with and without vernalization. However, in all those cases in which at least some plants flowered under either condition, the average number of days to peak bloom was smaller following vernalization than without it. It may be that this accelerated flowering indicates that the optimal conditions for all these plants involves a cold period, even though many bloom well without one.

In addition, the range of days to peak bloom from the first individual to the last in a group was smaller in vernalized plants than in non-vernalized ones, in 16 of 19 cases. Thus vernalization usually gives more control of flowering time in these species, which is useful when a target date must be established.

There is some relation between the effect of vernalization and the difference between the numbers of days to peak bloom with and without vernalization, in

the 19 species that bloomed with both treatments. The greater the relative difference, the more likely it is that the plant will be found to flower more fully after vernalization, although there are exceptions. The difference can be expressed as a ratio, by dividing the average number of days to peak bloom without vernalization, by the average number of days with vernalization. Ratios of 1.9–2.5 are found for four of the five plants that bloomed most fully with vernalization, and 1.6 for the exception, *Silene pratensis*. For those 14 species that bloomed about equally well with either treatment the ratios are from 1.3–1.6 for 11, including the incompletely dormant *Thlaspi arvense*, and 1.9–2.9 for the exceptions, *Arabis divaricarpa*, *Plantago major*, *Taraxacum officinale*, and the fully dormant *Thlaspi arvense*.

Many species with winter rosettes flower until the first heavy frost; we expected that these would flower readily without vernalization because in their natural environment they continued to produce flower buds as long as the weather remained fairly warm. *Berteroa incana*, *Capsella bursa-pastoris*, *Centaurea maculosa*, *Grindelia squarrosa*, *Silene pratensis*, *Taraxacum officinale*, and *Thlaspi arvense* are late bloomers in our area. Of these only *Grindelia squarrosa* required vernalization to bloom, but *Berteroa incana* and *Silene pratensis* flowered more fully after vernalization.

Two forms of *Thlaspi arvense* rosettes representing different growth states were found in late fall: fully dormant plants in which all the leaves had the shape typical of basal leaves in this species, and plants which had begun to bolt or were never fully dormant and which had a few basal type leaves beneath leaves of the cauline type. The latter plants grew very slightly in the cold room. Under both treatments these incompletely dormant plants bloomed much sooner than the fully dormant ones.

Two different soils were used for *Arabis divaricarpa*, *Gnaphalium obtusifolium*, *Hieracium aurantiacum*, and *Rudbeckia hirta*, to see if this would affect flowering. Some plants were potted in the original field soil and others were potted using the lighter greenhouse potting soil containing equal amounts of peat and horticultural styrofoam. The individuals in the greenhouse potting soil tended to be more robust and to bloom earlier with more flowers. All species not named above were potted using the greenhouse potting soil.

We have been able to add new species to those our taxonomy class already uses following the results of this experiment, and we can predict reliably the week in which they will bloom. We vernalize in most cases; as indicated in the table, vernalization usually makes possible a more accurate estimate of the number of days to peak bloom. We feel confident that this method will apply to other rosette-forming species as well, and thus enlarge the pool of plants available to winter taxonomy classes.

SUMMARY

Winter rosettes of 26 species were experimented with to determine if they could be forced to bloom in the greenhouse; trials were made both with and without vernalization. A seven week cold period was tried with nearly all and sufficed for most; a few needed a longer time. The length of time to peak bloom was recorded for each individual plant. Plants of all species bloomed after

vernalization. In 19 species at least some plants flowered without vernalization. Seven species required a cold period to bloom. Five required vernalization for full flowering but produced some flowers without the cold period. Fourteen bloomed about equally well with either method. In the latter 19 cases the average time to peak bloom was less for the vernalized plants; the range of days to peak bloom from the first to the last individual in a group was usually smaller in vernalized plants; and the difference between the average number of days to peak bloom with and without vernalization was usually greater in those plants that bloomed most fully following vernalization.

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REVIEW

COLLECTING AND PRESERVING PLANTS FOR SCIENCE AND PLEASURE. By Ruth B. (Alford) MacFarlane. Arco Publishing, Inc., New York, NY. 1985. vii + 184 pp., $8.95 paper bound, $13.95 hardbound.

People collect plants or parts of plants for a variety of reasons including using them in decorations and in scientific studies. These two uses are the subjects around which this clearly written book is built. The author carefully describes how to collect, identify, label, mount, and store plants for collections ranging from leaf collections for school projects to specimens for serious scientific study. The experience gained during her years as curator of the herbarium at Eastern Michigan University have been distilled into a very readable account of herbarium techniques for handling vascular plants, bryophytes, lichens, algae, and fungi. The line drawings, mainly by Jean Lynn Alred with a few by Richard MacFarlane, are clear and informative as well as attractive. My only quibbles pertain to some suggestions on handling fleshy fungi: food dehydrators are preferable to ovens for drying them and spore print color should always be judged from prints made on white paper by caps protected from desiccation.

The sections of the book that cover ornamental uses of plants, especially vascular plants, provide suggestions on design, and a variety of projects together with mention of plant materials appropriate to them. Anyone in search of ideas for plant-based crafts for all ages and abilities will find a wealth of material here.

Separate chapters are dedicated to the subjects of collecting, preserving, identifying, labeling, mounting and packaging, storage and display. Other chapters include a discussion of city botany, an introduction to what a herbarium is, and ornamental uses of plants both in two- and three-dimensional projects.

Two appendices give helpful information. The first includes a table of abbreviations, equivalents, and directions for temperature conversions. The second is a list of "Plants to Gather or Grow for Ornamental Purposes" which gives the scientific name and one common name for just over 40 kinds of plants, the part used, its color and stage when gathered, treatment, use, and comments. The index includes common and scientific names of plants discussed in the text, subjects and products covered, and names of people mentioned.

This book is highly recommended to anyone who is interested in learning about collecting and preserving plants for science or decoration or who is looking for an arm-chair tour of these subjects.—N. S. Weber

245 VERONICA VERNA (SCROPHULARIACEAE), AN OVERLOOKED ELEMENT OF THE NATURALIZED FLORA OF ONTARIO.

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Several species in the genus *Veronica* are well known members of Ontario's adventive and naturalized flora, having been introduced from Europe. Some of the most common and widespread of these include the perennials, *V. serpyllifolia* L. and *V. officinalis* L., and the annuals, *V. peregrina* L. var. *peregrina* and *V. arvensis* L. The last of these has two close relatives in Europe, *V. verna* L. and *V. dillenii* Crantz (Walters & Webb 1972). They are distinct from *V. arvensis* (see Table 1, in which *V. arvensis* and *V. verna* are contrasted morphologically), but are very similar to each other. They differ chiefly in style length and robustness, with *V. dillenii* having longer styles and taller stems (Walters & Webb 1972).

Fernald (1950), Gleason & Cronquist (1963), Boivin (1966), and Scoggan (1979) have reported the presence of *V. verna* in eastern North America (specifically, the Bruce Peninsula of Ontario). Gleason (1952) commented on the recent appearance of *V. dillenii* in Michigan. These appear to be the only references to the occurrence of these taxa in eastern North America. We have examined much of the Michigan material, and in our opinion, it is all *V. verna*. The only other North American locations for these taxa that we are aware of are Albany County, New York (a specimen in MICH, labelled as *V. dillenii,* is intermediate with *V. verna* in style length), Manitowoc County, Wisconsin, and Flagstone, British Columbia (the latter two are *V. verna;* specimens at DAO).

Since the mid-1970's, collections of *V. verna* have been made throughout central Ontario. Over 30 stations are now known. This paper summarizes our data on the distribution and ecology of this species in Ontario. We also speculate on its mode of dispersal, and it is contrasted with its close relative, *V. arvensis.*

MATERIALS AND METHODS

This study was conducted in two phases. The first involved site visits to various provincial parks, picnic grounds, and other heavily used sites with sandy substrates, where we predicted *V.*

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verna might occur. The second phase involved an examination of herbarium material of *V. verna* and *V. arvensis,* to determine the ranges of these taxa in Ontario. Location data obtained from the following herbaria were used to produce the maps in Figures 1 and 2: APM, CAN, DAO, HAM, LKHD, MICH, OAC, SLU, TRT, TRTE, and the personal herbaria of P. F. Maycock and R. E. Whiting (acronyms of herbaria according to Holmgren et al. 1981). The specific location data are available from the senior author.

RESULTS AND DISCUSSION

Although only one station of *V. verna* had previously been reported in Ontario (Fernald 1950, Scoggan 1979), we have found it to be quite common and widespread, particularly in central Ontario (Figure 1). Furthermore, it occurs in a definable habitat which makes its detection relatively simple. A great majority of the sites in which this species has been found are situated within provincial parks, usually in campgrounds. In fact, *V. verna* seems to thrive on dry, sandy, heavily disturbed campsites where the canopy of trees is not closed. It is rare or absent on shaded or wet sites. It may also occur on roadsides, in picnic areas, on open dunes, and on acidic (granitic) rock outcrops in thin seams of soil, as long as these sites are relatively open. An examination of Figure 1 indicates that most of the stations are found on the Canadian Shield. Those stations that are situated off of the Canadian Shield are located on acidic sand deposits (for example, in Presqu'ile, Pinery, and Turkey Point Provincial Parks). The characteristic habitat of *V. verna* is suggestive of a man-assisted dispersal mechanism. It is quite likely that the capsules of this species are routinely shattered by trampling on campsites and other disturbed sites. After this occurs, the seeds may be mixed with sand and other detritus on camping equipment, clothes, and vehicles. This may explain the ubiquity of this species in provincial parks near the southern edge of the Canadian Shield in Ontario. *Veronica arvensis* is widespread and common in southern Ontario (Figure 2). It is often found on roadsides, in lawns and gardens, and in various other disturbed habitats. It appears to be capable of tolerating a wider range of edaphic conditions (acidic and basic substrates are colonized). Like *V. verna,* it prefers open sites, but it may occur in partial shade, and in such sites, its stems may become quite elongated and matted. Both species flower relatively early in the season (beginning in late April), and fruit is usually set by mid-June.

We anticipate that *V. verna* will continue to be found in suitable habitats throughout southern and central Ontario in the future. To facilitate identification, Table 1 summarizes the morphological differences between these two very closely related species.

SUMMARY

Veronica verna L. is a widespread element of the naturalized flora in central Ontario. Previously reported only from a single location on the Bruce Peninsula, we have found it to be relatively common on open, sandy, disturbed, acidic sites throughout central Ontario. Since this species occurs most frequently in campsites, picnic grounds, and along roadsides, it would appear that its dispersal is accomplished largely through the agency of man. The present Ontario ranges of *V. verna* and its close relative, *V. arvensis* L., are mapped, and they are compared morphologically, to assist in their identification.
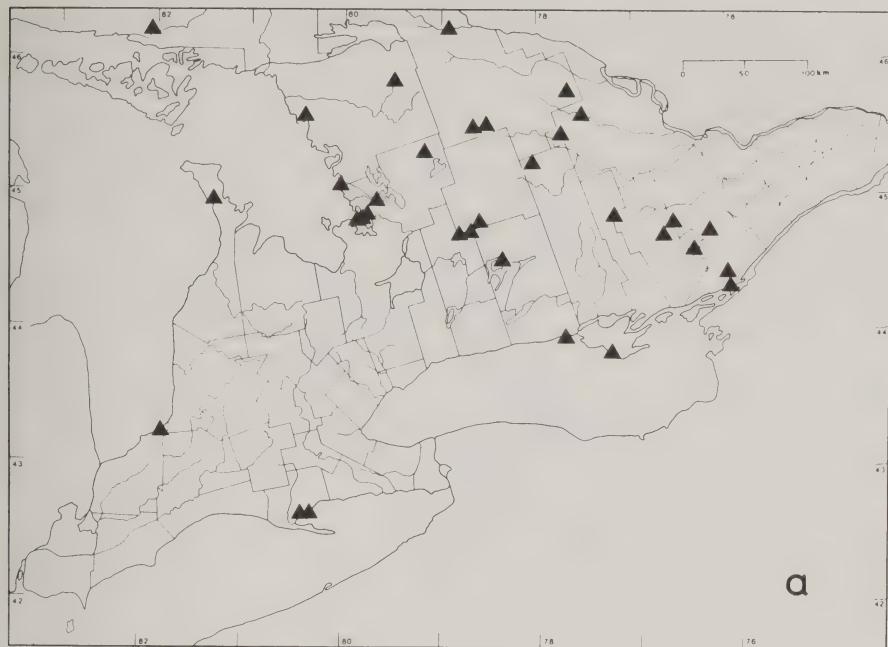
Figure 1: Distribution of *Veronica verna* in southern (a) and northern (b) Ontario.
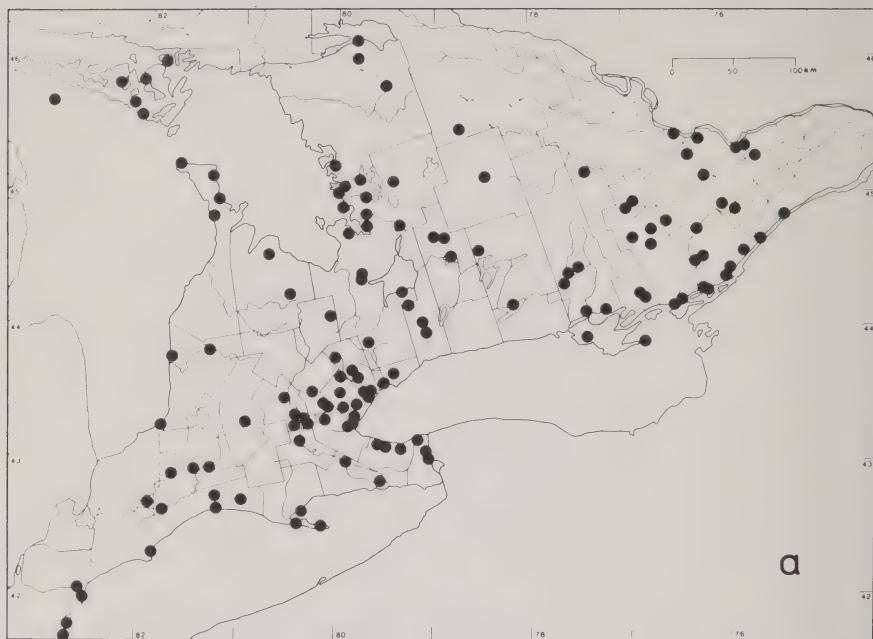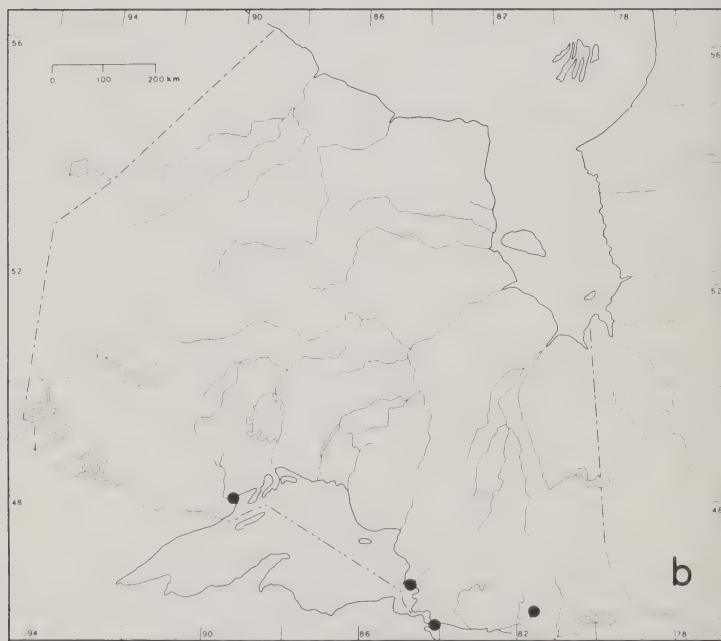
Figure 2: Distribution of *Veronica arvensis* in southern (a) and northern (b) Ontario.

TABLE 1: Morphological differences between *Veronica arvensis* and *V. verna*.

Character	*V. arvensis*	*V. verna*
leaf bases	median leaves sometimes with truncate or weakly cordate bases	median leaves usually with cuneate bases
leaf margins	median leaves crenately-toothed, not lobed	median leaves with several linear lobes on each side, pinnatifid
styles	ca. 0.6–1.0 mm long	ca. 0.5–0.6 mm long
capsule	subglabrous on sides, ciliate along margins, slightly longer than broad	glandular-hairy, slightly broader than long

ACKNOWLEDGMENTS

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ELEVENTH NORTH AMERICAN PRAIRIE CONFERENCE

The Eleventh North American Prairie Conference will be held 7–11 August 1988 at Lincoln Nebraska. The theme will be Prairie Pioneers: Ecology, History & Culture. For further information, contact: 1988 N.A. Prairie Conference, Department of Biology, University of Nebraska at Omaha, Omaha, NE 68182-0040.

REVIEW

FLOWERING PLANTS SMARTWEEDS TO HAZELNUTS. The Illustrated Flora of Illinois. By Robert H. Mohlenbrock and Paul M. Thomson, Jr. Southern Illinois University Press, Carbondale. 1986 ["1987"]. 228 pp. $35.00.

Like the previous 10 volumes in this series, the present one includes keys, rather full descriptions, illustrations, and Illinois distribution maps for all taxa. And, like previous volumes, it persists in displaying assorted irregularities. The authors cannot decide whether the names of higher taxa are plural (as the Code reminds us) or singular; so on p. 3, for example, we find one sentence beginning "The Polygonaceae is . . . ." and the next beginning "They are . . . ." On p. 5, the "Polygonaceae are considered . . . ." and also "The Polygonaceae is a family . . . ." Similarly, the Hamamelidales "consist" but eight pages later the Fagales "consists"—et passim. Is the authors aware how sloppy this looks? For some reason the publishers still insist on placing the abbreviated name of Linnaeus in a different size and style of type than those for all other authors of generic names.

The keys are in good contrasting form and ought to work *if* one's unknown plant displays unambiguously the one character (or at most two) cited. *Rumex crispus* can be keyed only by saying that each of the fruiting sepals bears a tubercle, while the text admits that sometimes there is only one such "grain." *Fagopyrum* can be distinguished from smooth-stemmed *Polygonum* in the key only by whether the leaves [blades] are "hastate-deltoid," but the text says that in *P. convolvulus* they are "deltoid to ovate" and in *F. esculentum,* "hastate to deltoid."

Perhaps the prime paragraph of doubletalk is on p. 52, where the fruit in *P. scandens* "usually always [*sic*] exceeds 10 mm" when contrasted with that of *P. cristatum,* whereas the description of *P. scandens* says the achene (properly defined in the glossary as a type of fruit) is 3–5 mm long. "In combining *P. dumetorum* with *P. cristatum*" the authors consider certain characters insignificant; but in the next paragraph they say that "*P. dumetorum* is actually applicable to a different species." There are other instances in which synonymy is not very lucid. On *what grounds* do some botanists "give" *Rumex mexicanus* the name *R. triangulivalvis? Fagopyrum sagittatum* Gilib. is not an illegitimate name; it is not validly published. Only *Tovara virginiana* is given as a synonym of *Polygonum virginianum*. not the correct *Antenoron virginianum* (*Tovara* having been rejected since 1959). The listing of "*Quercus muehlenbergii* var. *alexanderi* (Britton) Farwell" overlooks Farwell's explicit statement (in 1924) that his name was independent of Britton's (a complicated story altogether, futher discussed in Mich. Bot. 24: 119–120. 1985). I am unaware of any basis for taking up *Corylus rostrata* for beaked hazelnut, instead of the earlier *C. cornuta,* which is not even listed in synonymy although used by all current manuals and checklists.

I applaud the authors' decision to maintain *Polygonum* in a broad sense, if not their fine splitting of some of the species. Figures of leaf trichomes and of longitudinal sections of acorns should prove helpful with *Quercus.* I cannot help but wonder whether records of *Betula populifolia* attributed to Illinois are, at least in part, based on plants of *B. pendula* escaped from cultivation, as is the case in Michigan. The names *Betula* × *sandbergii* and *B.* × *purpusii* are both said to apply to hybrids of the same parentage (a nomenclatural impropriety at best), repeating an error in *Gray's Manual. B.* × *sandbergii* is the hybrid of *B. papyrifera* (not *B. alleghaniensis*) with *B. pumila*—as abudantly discussed in papers by Barnes, Dancik, and others. Mention of "The Village Blacksmith" under chestnut (*Castanea dentata*) is quite irrelevant, since Longfellow's "spreading chestnut" was the horse-chestnut (*Aesculus hippocastanum,* in quite a different family).

For those unfamiliar with Thorne's system, used in this series, it should be noted that the present volume includes 86 species of Polygonaceae, Hamamelidales, and Fagales. The price thus averages over 40 cents per species. The *Flora of the Great Plains,* published the same year and also by a university press, averages about 1.8 cents per species. Comparisons are odious, but the consumer must reflect on whether the inclusion of maps and illustrations in a flora is worth such a difference. Nevertheless, the Illustrated Flora of Illinois should prove to be of some use in neighboring areas as well, such as southern Michigan.—E. G. Voss

245 CAREX BUSHII MACK., A SEDGE NEW TO MICHIGAN

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During July of 1985, the authors extensively collected sedges on Beaver Island (Charlevoix County) in the Beaver Island archipelago. This group of islands is located in northern Lake Michigan, approximately 32 miles northwest of Charlevoix. Beaver Island, covering 58.4 square miles, is the largest of the islands. A synopsis of the floristic and geologic history can be found in Knapp et al. (1969).

One of the species collected, *Carex bushii* (Menapace 16, MICH) is the first authenticated record of this species for Michigan (Reznicek, per. com.) A previous collection by O. A. Farwell from Keweenaw County exists, but was rejected on phenological and phytogeographical grounds by both Hermann (1941, 1951) and Voss (1972) as being mislabeled. The Beaver Island locality for *C. bushii* (Sec. 10, T38N, R10W) is just east of Egg Lake. The plants were growing on dry, sandy soil in moderate numbers in association with *Pinus strobus, Pteridium aquilinum,* and *C. pallescens.* Much of its habitat was part of the original homesteads farmed by the Strangites. These people had originally been part of the Church of Jesus Christ of Latter Day Saints. After the death of its founder Joseph Smith, they followed the leadership of James Strang. During the period 1848–1850, they came to Beaver Island seeking a place to live in accordance with their beliefs. Since their departure in 1856, the land has under-gone old field succession.

Carex bushii belongs in section *Virescentes,* in which Mackenzie (1935) recognized nine species in North America. Four of these have previously been known from Michigan: *C. virescens* Willd., *C. swanii* (Fern.) Mack., *C. pallescens* L., and *C. hirsutella* Mack. (Voss 1972). *Carex bushii* is distinguished from *C. virescens* and *C. swanii* by its glabrous perigynia in contrast to the pubescent perigynia of the latter two species. It is distinguished from *C. pallescens* by the gynecandrous terminal spike as opposed to the entirely staminate terminal spike of *C. pallescens. Carex bushii* can be separated from *C. hirsutella* by its longer (2.5–3.75mm) perigynia; those of *C. hirsutella* being typically 2–2.5mm long (Mohlenbrock 1986).

In Illinois, *Carex bushii* is occasional to common in the southern part of the state, with its northern most station being in McDonough County (Mohlenbrock 1986). Deam (1940) cites it from Indiana only in Posey and Spencer Counties, which are in the extreme south. There are no records of this species for Wisconsin (Zimmerman 1976), Ohio (Weishaupt 1971), or Ontario (Scoggan 1978). Thus, the Beaver Island population of *C. bushii* is disjunct by about 400 miles from the continuous range of the species. Examination of our other *Carex* collections also revealed several taxa previously unreported for the Beaver Island

flora (Hermann 1941, 1951; Voss 1972). These are: *C. buxbaumii* Wahl. (Menapace 64), *C. granularis* Willd. (Menapace 78), *C. lanuginosa* Michx. (Menapace 40), and *C. scabrata* Sch. (Menapace 8). Voucher specimens of these species cited are in the herbarium of the major author.

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THE GILLETTE FUND

A bequest of $10,000 from Genevieve Gillette has established an endowment at The University of Michigan for the University Herbarium. The income is to be used to support ''systematic and floristic research on Michigan plants, including algae, fungi, bryophytes, and vascular plants, and, if needed, for the publication of the results of such research.'' Miss Gillette's broad interests in the natural resources of Michigan, including its plant life and its natural areas, will be documented in another issue. The endowment she established is tangible evidence of her concern for continuing study of these resources.

Persons and organizations who wish to honor Genevieve Gillette and/or to invest in ongoing research on Michigan plants are welcome and encouraged to add to this endowment (or, of course, to establish an endowment of their own). Friends and admirers of Miss Gillette may specify The Gillette Fund in thier own estate plans, or may send checks (payable to The University of Michigan) to the Director of the Herbarium (North University Bldg., Ann Arbor 48109), who will see that funds are deposited to the correct account and appropriately acknowledged.

246 THE ELEVENTH ANNUAL A. H. SMITH LAKES STATES FORAY

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The eleventh annual Smith Foray was held 19–22 September 1985 at Camp Gray, Sauk County, in the south-central driftless area of Wisconsin. Janet Phelps, UW–Baraboo, served as organizer and host. Attendance was excellent; 49 persons enjoyed the collecting and tolerated the sometimes rainy weather. Friday morning was spent at the Potter Property (UW Foundation), which contains a mixed deciduous woods and small pine plantation. The majority of forayers visited Pine Hollow (Nature Conservancy) in the afternoon, while one group went to Natural Bridge State Park (Wisconsin DNR) and another chose to visit a sand prairie and pine plantation along the Wisconsin River (Lone Rock—Wisconsin DNR). Rain on Saturday morning did not diminish enthusiasm for collecting at the Aldo Leopold Preserve along the Wisconsin River and seeing the area that seved as inspiration for his *Sand County Almanac*. The afternoon was spent drying off, working on specimens, and collecting at Camp Gray. Michael Tansey, of Indiana University, entertained the group with after-dinner lectures on Friday and Saturday nights.

Habitats visited during the foray contained a variety of plant associations and provided a good diversity of fungi. Among the most interesting finds were *Chionosphaera apobasidialis* and *Septobasidium carestianum* on *Cornus foemina* subsp. *racemosa*. *Chionosphaera* was originally described by Cox (1976) from dead branches of *Quercus macrocarpa* and *Carpinus caroliniana* in Illinois. The diminutive size of the basidiocarps (0.5–3 mm tall) and the resemblance to a myxomycete or synnematous deuteromycete may account in part for its being rarely collected or identified. The only North American collections of *Septobasidium carestianum* cited by Couch (1938) were made by Dearness in Ontario, Canada. Harrison (1972) reported two collections from Washtenaw County, Michigan, and one earlier collection made near Dexter, Michigan, by L. E. Wehmeyer and A. H. Smith. Four additional records were cited by Harrison as a result of correspondence with Couch: two from New York, one from Ontario on *Alnus incana,* and one from Quebec on *Viburnum alnifolium*. The specimens of *S. carestianum* from Sauk County, Wisconsin, are apparently the first record of this species in the state. Many of the other taxa in the list are commonly identified in the Lakes States whenever mycologists congregate. Sincere thanks are extended to the following persons for their identifications: Tim Began, Harold Burdsall, Wm. Bridge Cooke, Dean Glawe, David McLaughlin, Dana Richter, and Walter Sundberg. Voucher specimens of many species have been deposited in the Milwaukee Public Museum herbarium or in the herbaria of persons contributing identifications.

Knowledge of the occurrence and distribution of many saprotrophic or mycorrhizal ascomycetes and basidiomycetes in Wisconsin is fragmentary. Early contributions by Bundy (1883), Trelease (1889), Brown and Ferneckes (1902), Gilbert (1910), Neuman (1914), and Dodge (1914) give some indication of the diversity of fleshy fungi found in various areas of the state, but are of limited value because herbarium specimens are lacking. No significant regional studies of Wisconsin ascomycetes or basidiomycetes have appeared in recent years. Other records of higher fungi from the state are widely scattered in the taxonomic literature. In contrast, the work of J. J. Davis and H. C. Greene has provided extensive knowledge concerning the plant-parasitic fungi of Wisconsin. A complete listing of Davis's and Greene's publications is provided by Greene and Curtis (1955).

The following list, although far from a complete compilation of fungi of the region, includes 174 species found on the foray in south-central Wisconsin. Extensive further research is needed throughout the state to elucidate thoroughly the mycobiota of Wisconsin.

MYXOMYCETES
  Liceales
  Reticulariaceae
    Reticularia splendens Morg.
ASCOMYCETES
  Diatrypales
  Diatrypaceae
    Diatrype albopruinosa (Schw.) Cooke
    Diatrype stigma (Hoffm. : Fr.) Fr.
    Diatrypella favaceae (Fr.) Ces. & DeNot.
  Hysteriaceae
    Hysterium insidens Schw., *Coniosporium*
      state
  Dothidiales
  Venturiaceae
    Apiosporina morbosa (Fr.) v. Arx
  Helotiales
  Helotiaceae
    Bisporella citrina (Fr.) Korf & Carpenter
    Chlorociboria aeruginascens (Nyl.)
      Kanouse ex Ram., Korf & Batra
  Pezizales
  Helvellaceae
    Helvella crispa Fr.
    Helvella sp.
  Humariaceae
    Scutellinia erinacea (Schw.) Kuntze
  Pezizaceae
    Otidea sp.
  Sphaeriales
  Xylariaceae
    Daldinia concentrica (Bolt. : Fr.) Ces. &
      DeNot.
    Hypoxylon rubiginosum (Pers. : Fr.) Fr.
    Lopadostoma gastrinum (Fr.) Traverso
    Xylaria polymorpha (Pers. ex Mer.) Grev.

DEUTEROMYCETES
  Bactridiales
  Coniosporiaceae
    Trichothecium roseum (Pers.) Link ex
      S.F. Gray
  Moniliales
  Moniliaceae
    Rhinotrichella globulifera Arnaud ex de
      Hoog on *Fomes fomentarius*
HOLOBASIDIOMYCETES —
    Hymenomycetes
  Agaricales
  Amanitaceae
    Amanita brunnescens Atk.
    Amanita cholorinosima Fr.
    Amanita citrina S.F. Gray
    Amanita constricta nom. prov.
    Amanita daucipes (Mont.) Lloyd
    Amanita flavoconia Atk.
    Amanita inaurata Secr.
    Amanita muscaria (Fr.) Hook.
  Boletaceae
    Boletus badius Fr.
    Suillus luteus (L. : Fr.) S.F. Gray
    Suillus pictus (Pk.) A.H. Smith & Thiers
  Cortinariaceae
    Galerina autumnalis (Pk.) A.H. Smith &
      Sing.
  Lepiotaceae
    Lepiota procera (Scop. : Fr.) S.F. Gray
    Lepiota cristata (Fr.) Kummer
  Rhodophyllaceae
    Entoloma abortivum (Berk. & Curt.)
      Donk
  Strophariaceae
    Naematoloma sublateritum (Fr.) Karst.

Pholiota aurivella (Batsch : Fr.) Kummer
Tricholomataceae
Armillariella mellea (Fr.) Karst.
Asterophora lycoperdoides Ditmar ex S.F. Gray
Baeospora myosura (Fr.) Sing. on *Pinus strobus* cones
Clitocybe clavipes (Pers. : Fr.) Kummer
Collybia semihirtipes (Pk.) Halling
Collybia subnuda (Ellis ex Pk.) Gilliam
Crinipellis setipes (Pk.) Sing.
Inocybe geophylla var. *lilacina* Pk.
Laccaria laccata (Fr.) Berk. & Br.
Laccaria ochropurpurea (Berk.) Pk.
Laccaria trullisata (Ellis) Pk.
Marasmius siccus (Schw.) Fr.
Marasmius sp.
Panellus serotinus (Pers. : Fr.) Kuhn.
Panellus stypticus (Fr.) Karst.
Panus rudis Fr.
Pleurotus sapidus (Schulz. in Kalchbr.) Sacc.
Strobilurus albipilatus (Pk.) Wells & Kempton
Tricholoma flavovirens (Pers. : Fr.) Lundell
Xeromphalina campanella (Fr.) Kuhn. & Marie
Aphyllophorales
Auriscalpiaceae
Lentinellus ursinus (Fr.) Kuehn.
Cantharellaceae
Cantharellus cibarius Fr.
Cantharellus cinnabarinus Schw.
Craterellus fallax A.H. Smith
Clavulinaceae
Clavulina amethystina (Fr.) Donk
Clavulina cristata (Fr.) Schroet.
Corticiaceae
Aleurodiscus cerrusatus (Bres.) Hoehn. & Litsch.
Aleurodiscus oakesii (Berk. & Curt.) Hoehn. & Litsch.
Cylindrobasidium albulum (Atk. & Burt) J. Erikss. & Hjortst.
Dendrothele alliacea (Quél.) Lemke
Dendrothele microspora (Jacks. et Lemke) Lemke
Fibulomyces septentrionalis (J. Erikss.) Jul.
Hyphoderma litschaueri (Burt) J. Erikss. & Strid
Hyphoderma medioburiense (Burt) Donk
Hyphoderma puberum (Fr.) Wallr.
Hyphoderma setigerum (Fr.) Donk
Hyphodontia arguta (Fr.) J. Erikss.

Hyphodontia setulosa (Berk. & Curt. in Berk.) Maas G.
Hyphodontia sp.
Hypochnicium vellereum (Ell. & Craip.) Parm.
Peniophora sp.
Phanerochaete chrysorhiza (Torr. in Eaton) Budington & Gilbn.
Phanerochaete filamentosa (Berk. & Curt.) Burdsall in Parker & Roane
Phanerochaete jose-ferreirae (Reid) Reid
Phanerochaete leavis (Fr.) Erikss. & Ryv. in Eriksson
Phanerocheate rimosa (Cooke) Burdsall
Phanerochaete sanguinea (Fr.) Pouz.
Phlebia brevispora Nakas. in Nakasone & Eslyn.
Radulomyces sp.
Trechispora farinacea (Pers. ex Fr.) Liberta
Ganodermataceae
Ganoderma applanatum (Pers. ex Wallr.) Pat.
Gomphaceae
Kavinia himantia (Schw.) J. Erikss.
Hericiaceae
Hericium corralloides (Fr.) S.F. Gray
Hericium erinaceus (Bull. : Fr.) Pers.
Hydnaceae
Hydnellum scrobiculatum (Fr.) Karst.
Hydnum repandum L. : Fr.
Hymenochaetaceae
Coltricia cinnamomea (Jacq. ex Pers.) Murr.
Coltricia perennis (Fr.) Murr.
Hydnochaete olivacea (Schw. : Fr.) Banker
Inonotus tomentosus (Fr.) Gilb. & Budd.
Phellinus everhartii (Ell. & Gall.) Ames
Phellinus igniarius (Fr.) Quél.
Phellinus punctatus (Fr.) Pilat
Phellinus sp.
Lachnocladiaceae
Vararia investiens (Schw.) Karst.
Meruliaceae
Meruliopsis spissus (Schw.) Parm.
Phlebia rufa (Fr.) M.P. Christiansen
Plicaturopsis crispa (Fr.) Reid
Polyporaceae
Albatrellus cristatus (Pers. : Fr.) Kotl. & Pouz.
Antrodia malicola (Berk. & Curt.) Donk
Bjerkandera adusta (Willd. : Fr.) Karst.
Bjerkandera fumosa (Fr.) Karst.
Ceriporia spissa (Schw.) Raichenberg
Cerrena unicolor (Bull. : Fr.) Murr.
Coriolus pubescens (Schum. : Fr.) Quél.

Coriolus versicolor (L. : Fr.) Quél.
Daedalea quericina Fr.
Daedaleopsis confragosa (Bolt. : Fr.)
    Schroet.
Favolus alverolaris (DC. : Fr.) Quél.
Fomes fomentarius (L. : Fr.) Kickx
Gloeoporus dichrous (Fr.) Bres.
Grifola frondosa (Fr.) S.F. Gray
Irpex lacteus (Fr. : Fr.) Fr.
Perenniporia ohiensis (Berk.) Ryv.
Phaeolus schweinitzii (Fr.) Pat.
Piptoporus betulinus (Bull. : Fr.) Karst.
Polyporus badius (S.F. Gray) Schw.
Polyporus sulphureus var. *semialbinus*
    Pk.
Polyporus varius Pers. : Fr.
Polyporus sp.
Poria spp.
Trichaptum abietinum (Fr.) Ryv.
Trichaptum biformis (Fr. in Kl.) Ryv.
Trichaptum subchartaceum (Murr.) Ryv.
Tyromyces albellus (Pk.) Bond. & Sing.
Tyromyces sp.
Pycnoporus cinnabarinus (Jack. : Fr.)
    Karst.
Porotheliaceae
Cyphella sp.
Merismodes fasciculatus (Schw.) Earle
Punctulariaceae
Phaeophelibia strigo-zonata (Schw.)
    W.B. Cooke
Schizophyllaceae
Solenia ochraceus (Hoffm.) Berk.
Schizophyllum commune Fr.
Steccherinaceae
Steccherinum ochraceum (Pers. : Fr.)
    S.F. Gray
Stereaceae
Stereum hirsutum (Willd. : Fr.) S.F. Gray
Stereum ostrea (Blume & Nees : Fr.) Fr.
Stereum striatum (Fr.) Fr.
Thelephoraceae
Thelephora terrestris Fr.
Thelephora sp.
Tomentella bresadolae (Brinkm. ex Bres.)
    Bourd. & Galz.
HOLOBASIDIOMYCETES—Gasteromycetes
Lycoperdales
Geastraceae
Geastrum sp.
Lycoperdaceae
Bovista pila Berk. & Curt.
Calvatia craniformis (Schw.) Fr.
Calvatia cyathiformis (Bosc) Morg.
Lycoperdon marginatum Vitt.
Lycoperdon perlatum Pers. : Pers.

Lycoperdon pulcherrimum Berk. & Curt.
Lycoperdon pyriforme Schaeff. : Pers.
Nidulariales
Nidulariaceae
Crucibulum vulgare Tul.
Phallales
Phallaceae
Mutinus caninus var. *albus* Zeller
Phallus impudicus Pers.
Sclerodermatales
Astraeceae
Astraeus hygrometricus (Pers.) Morg.
Sclerodermataceae
Pisolithus tinctorius (Pers.) Coker &
    Couch
Scleroderma albidum Pat. & Trab. em.
    Guzmán
Scleroderma areolatum Ehrenb.
Scleroderma citrinum Pers.
Scleroderma flavidum Ellis & Everhart
Scleroderma michiganense (Guzmán)
    Guzmán
Scleroderma polyrhizon Pers.
HETEROBASIDIOMYCETES
Atractiellales
Chionosphaeraceae
Chionosphaera apobasidialis Cox
Phleogenaceae
Phleogena faginea (Fr.) Link
Septobasidiales
Septobasidiaceae
Septobasidium carestianum Bres. on
    Cornus foemina Mill. subsp. *racemosa*
Tremellales
Tremellaceae
Basidiodendron eyrei (Wakef.) Luck-
    Allen
Exidia glandulosa Fr.
Exidia recisa Fr.
Tremellodendron pallidum (Schw.) Burt
Tulasnellales
Tulasnella violea (Quél.) Bourd. & Galz.
Uredinales
Coleosporaceae
Coleosporium asterum (Diet.) Syn. on
    Solidago sp.
Cronartiaceae
Cronartium ribicola Fischer on *Ribes*
    spp.
Puccinaceae
Gymnosporangium juniperi-virginianae
    Schw.
Pucciniastraceae
Uredinopsis osmundae Mag. on *Osmunda*
    cinnamomea

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Harrison, K. A. 1972. A rare *Septobasidium* on scale insects on *Cornus* found in Michigan. Michigan Bot. 11: 74–77.

Neuman, J. J. 1914. The Polyporaceae of Wisconsin. Wisconsin Geol. & Nat. Hist. Survey Bull. 33, Sci. Ser. 10.

Trelease, W. 1889. The morels and puffballs of Madison. Trans. Wisconsin Acad. Sci. 7: 105–120.

PUBLICATION OF INTEREST

A FIELD GUIDE TO SOUTHERN MUSHROOMS. By Nancy S. Weber & Alexander H. Smith, with photographs by Dan Guravich. University of Michigan Press, Ann Arbor, MI. 1985. 280 pp., 245 color plates, hardbound, $16.50.

Although this book deals with the mushroom flora of the southern regions of the continent, many of the included species range north into the Great Lakes region. It will be useful to amateurs and professionals alike. The illustrations are especially outstanding. The details of the mushrooms are sharply defined and the colors are almost invariably accurate for each species, indicating that each photograph was taken by a dedicated mushroom hunter and reproduced under the critical eyes of craftsmen. The introduction is strong in the history of mycology in the southeastern regions of the continent. The details about the early mycologists who collected in the region open up a most interesting glimpse of the difficulties that these pioneers faced in finding names for the species discovered and how this information was recorded for posterity. An important and very useful section is devoted to summaries of the groups of toxins found in our mushrooms. The great surge of interest by amateurs in mycophagy and the numerous possibilities of confusing dangerous pairs of look-alikes makes it very useful to have information close at hand if and when mistakes are made. The authors draw attention to the richness of the mushroom flora of the region with an estimate that between 3000 and 5000 species will eventually be recorded from the area. It is immediately evident that the 240 species described and illustrated only represent some 5 to 8 percent of the taxa to be found there. Of course, the *Guide* illustrates the larger showy species that are most frequently collected. The *Guide* contains examples of species in 23 groups of fungi and amateurs can thus key their finds into broad categories. The choice of species selected to represent these groups has resulted in some spectacular pictures of fungi strange to northern eyes. The *Guide* has treated four groups of fungi in some detail. There are 50 species illustrated in various genera of the family Boletaceae and 20 in the genus *Lactarius* indicating the professional interests of the authors. There are also species in the Lepiotaceae and Amanitaceae that are unusual and will be of interest to professionals studying these groups. Do not expect that this guide will enable you to identify everything you find in southern regions or everything with southern affinities that appears in the Great Lakes area. It is recommended as a guide to mushroom hunters for its accuracy and will be appreciated for the excellent quality of its illustrations.—K. A. Harrison, Adjunct Research Associate, University of Michigan Herbarium.

MICHIGAN PLANTS IN PRINT

New Literature Relating to Michigan Botany

The previous installments of this section appeared in the numbers from March 1982 to January 1983. After regrettable diversions by the compiler, publication resumes, with the continued aim of listing new literature relating to Michigan botany under four categories: A. Maps, Soils, Geology, Climate, General (new maps and selected bulletins or articles on matters useful to field naturalists and students of plant distribution); B. Books, Bulletins, etc., and C. Journal Articles (listing, respectively, all separate publications and all articles in other periodicals which cite Michigan specimens or include research based on plants of wild origin in Michigan—not generally including work on cultivated plants nor strictly economic aspects of forestry, conservation, or agriculture); D. History, Biography, Exploration (institutions as well as travels and lives of persons with Michigan botanical connections). When the subject matter or relation to Michigan is not clear from the title, annotations are added in brackets.

—E. G. V.

A. MAPS, SOILS, GEOLOGY, CLIMATE, GENERAL

Leatherberry, Earl C., & David W. Lime. 1981. Unstaffed Trail Registration Compliance in a Backcountry Recreation Area. U. S. Dep. Agr. For. Serv. Res. Pap. NC-214. 11 pp. [A clear and interesting illustrated report on study made in 1978 and 1979 in the McCormick Experimental Forest, one of the Upper Peninsula's choicest wild places.]

Peterson, Warren L. 1986. Late Wisconsinan Glacial History of Northeastern Wisconsin and Western Upper Michigan. U. S. Geol. Surv. Bull. 1652. 14 pp. + map. $2.25. [Map shows glacial deposits east almost to Republic and Iron Mountain; describes four ice advances and the proglacial lakes ponded south of the last two.]

Petitti, Debbi. 1981. Future of Michigan's sand dunes. Mich. Sci. Action 44: 4–9. [General account of dune ecology and importance of sand to industry, with two pages of photos of sand mining.]

Simard, Albert J., & Richard W. Blank. 1983. Fire history of a Michigan jack pine forest. Mich. Academ. 15: 59–71. [Dates and interpretation for Mack Lake area (Oscoda Co.) for the past 160 years.]

(U.S. Department of Agriculture, Soil Conservation Service.) Soil surveys for the following counties have been distributed since our previous listings in March 1982: Allegan, Berrien, Branch, Isabella, Kent, Lake & Wexford, Mecosta, Missaukee, Oakland, St. Joseph, Tuscola, and Van Buren. [These all include complete aerial photographic coverage, with boundaries of soil types overprinted; such surveys are very useful in planning or interpreting field work. To save space, we do not list them individually here. Michigan surveys are available from the Soil Conservation Service, USDA, 1405 S. Harrison Rd., Room 101, East Lansing, Michigan 48823.]

(U.S. Geological Survey.) Over 200 new topographic maps (7 1/2-minute quadrangles) have been issued for Michigan since the last listing here in May of 1982. [These are "provisional" maps but there is no prediction as to when, if ever, final versions will be issued. Space does not permit listing them all. The price is now $2.50 each, and the address is U. S. Geological Survey, Map Distribution, Federal Center, Bldg. 41, Box 25286, Denver, Colorado 80225. Indexes are available, and full information on new maps appears monthly in "New Publications of the U. S. Geological Survey," distributed without charge.]

B. BOOKS, BULLETINS, SEPARATE PUBLICATIONS

Albert, Dennis A., Shirley R. Denton, & Burton V. Barnes. 1986. Regional Landscape Ecosystems of Michigan. School of Natural Resources, University of Michigan. 32 pp. + map. [Presents 46 subdistricts, in 20 "districts," defined on a practical and realistic integration of climate and physiography, with vegetational consequences.]

Argus, George W. 1986. The Genus Salix (Salicaceae) in the Southeastern United States. Syst. Bot. Monogr. 9. 170 pp. $20.00. [Small outline range maps for several of the species indicate Michigan distribution; only two of the species covered have not been reported from Michigan, and we do have a few additional species (including all three "excluded species"), but the keys, taxonomic information, and illustrations will be helpful in our region.]

Brewer, Richard (ed.). 1983. Proceedings of the Eighth North American Prairie Conference. Dept. Biology, Western Michigan University, Kalamazoo 49008. 176 pp. $28.00. [See review in Mich. Bot. 23: 120 (1984) and individual listings below for articles by Pleznac, Stephenson, Stuckey, and Thompson.]

Clambey, Gary K., & Richard H. Pemble (eds.). 1986. The Prairie: Past, Present and Future. Proceedings of the Ninth North American Prairie Conference. Tri-College University Center for Environmental Studies, 306 Ceres Hall, N. D. State Univ., Fargo, N. D. 58105. 264 pp. $20.00. [Several papers include Michigan work; see individual listings below for Pippen & Chapman, Thompson & Jaworski, and Evans.]

Hix, David M., Burton V. Barnes, & John A. Witter. 1983. Site Classification of Selected Spruce-Fir-Dominated Ecosystems of the Ottawa National Forest, Upper Peninsula of Michigan. Mich. Coop. Forest Pest Managem. Progr. Tech. Rep. 83-14. 89 pp. [Analysis of 21 dryland and 4 wetland units, in anticipation of correlations between diversity and vulnerability to spruce budworm infestation.]

Loomis, Robert M. 1982. Seasonal Variations in Ash Content of Some Michigan Forest Floor Fuels. U. S. Dep. Agr. For. Serv. Res. Note NC-279. 3 pp. [Data from three Lower Peninsula counties on total and silica-free ash content of 10 tree species plus mixed hardwood forest floor litter and bracken, from determinations made at four times of the year. Differences due to species were generally more important than those due to season.]

McDaniel, Sidney. 1971. The Genus Sarracenia (Sarraceniaceae). Bull. Tall Timbers Res. Sta. 9. 36 pp. [*S. purpurea* mapped at scattered Michigan localities, and f. *heterophylla* cited from "Montgomery" (i. e. Montmorency) Co.]

Sheviak, Charles J. 1982. Biosystematic Study of the Spiranthes cernua Complex. New York St. Mus. Bull. 448. 73 pp. $5.00 [Includes keys, descriptions, and ample illustrations; distribution maps show occurrence in Michigan of *S. cernua, S. magnicamporum,* and *S. ochroleuca;* chromosome counts of the latter reported from Saginaw Co.]

C. JOURNAL ARTICLES

Abrams, Marc D., & Donald I. Dickmann. 1982. Early revegetation of clear-cut and burned jack pine sites in northern lower Michigan. Canad. Jour. Bot. 60: 946–954. [Unburned clearcut sites were dominated by *Carex pensylvanica;* burned sites showed greater species richness.]

Abrams, Marc D. 1984. Uneven-aged jack pine in Michigan. Jour. For. 82: 306–307. [Study in northern Lower Peninsula indicates that clearcutting and burning do not adequately regenerate jack pine.]

Abrams, Marc D., & Donald I. Dickmann. 1984. Floristic composition before and after prescribed fire on a jack pine clear-cut in northern lower Michigan. Canad. Jour. For. Res. 14: 746–749. [Study in Roscommon county supports Egler's "initial floristic composition" model.]

Abrams, Marc D., Douglas G. Sprugel, & Donald I. Dickmann. 1985. Multiple successional pathways on recently disturbed jack pine sites in Michigan. For. Ecol. Managem. 10: 31–48. [Study in Roscommon, Crawford, Oscoda, and Ogemaw counties.]

Anderson, Roger C., & Michael H. Beare. 1983. Breeding system and pollination ecology of Trientalis borealis (Primulaceae). Am. Jour. Bot. 70: 408–415. [Study conducted at the University of Michigan Biological Station, Cheboygan Co.]

Argus, George W. 1986. Studies of the Salix lucida and Salix reticulata complexes in North America. Canad. Jour. Bot. 64: 541–551. [Small-scale distribution map for *S. lucida* ssp. *lucida* has dots throughout Michigan.]

The March issue (Vol. 26, no. 2) and the May issue (Vol. 26, no. 3) were mailed June 11, 1987.

CONTENTS

On the cover: *Spathulariopsis velutipes*. Photo by E. B. Mains.